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(54) **HUMERAL ARTHROPLASTY**

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(65) **Prior Publication Data**

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(51) **Int. Cl.**

A61F 2/40 (2006.01)

A61F 2/30 (2006.01)

(52) **U.S. Cl.**

CPC ***A61F 2/4014*** (2013.01); ***A61F 2/4003*** (2013.01); *A61F 2002/3028* (2013.01); *A61F 2002/30278* (2013.01); *A61F 2002/30803* (2013.01); *A61F 2002/30892* (2013.01); *A61F 2002/4007* (2013.01)

(58) **Field of Classification Search**

CPC A61F 2/36–2/3676; A61F 2/3859; A61F 2/3877; A61F 2/4059; A61F 2002/30118; A61F 2002/3012; A61F 2002/4085; A61F 2002/4018; A61F 2002/4022; A61F 2002/4241–2002/4248; A61F 2/4014–2/4261; A61F 2002/30112; A61F 2002/30121; A61F 2002/30123; A61F 2002/30199; A61F 2002/30245–2002/30261

USPC 623/21.12–21.14, 22.43, 23.12, 23.11, 623/23.15, 19.11–19.14

See application file for complete search history.

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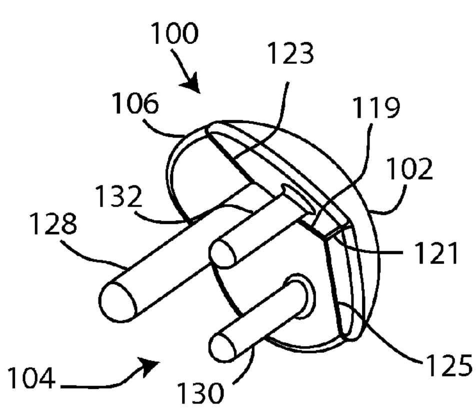
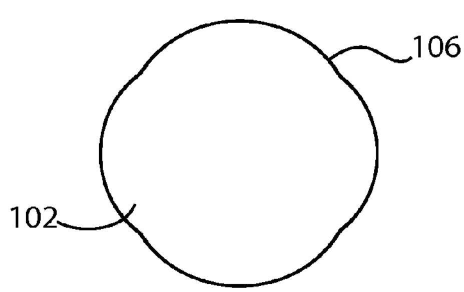
(57) **ABSTRACT**

Arthroplasty components include an articular surface and a bone-facing surface. The bone-facing surface includes a concave arrangement of planar surfaces which converge as they approach a middle portion of the articular surface. Instruments and implantation methods are also disclosed.

20 Claims, 66 Drawing Sheets





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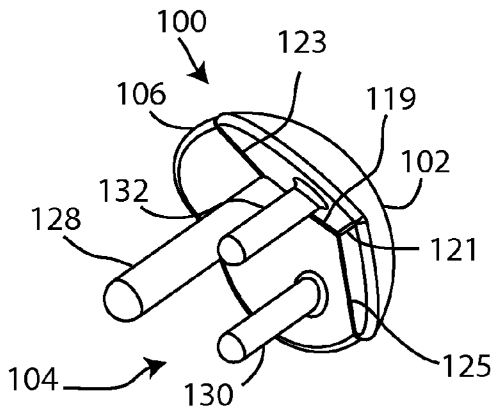

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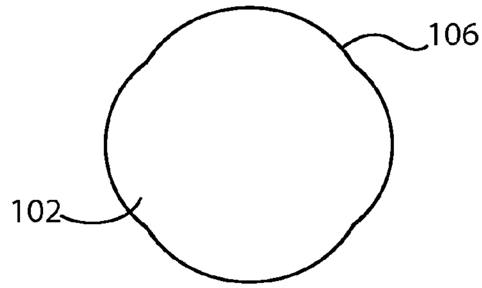

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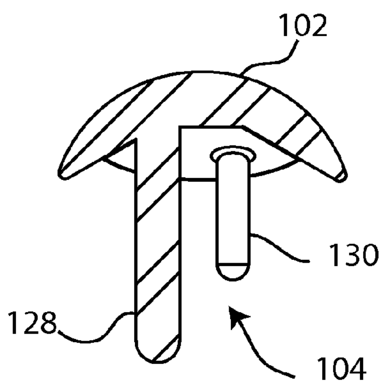

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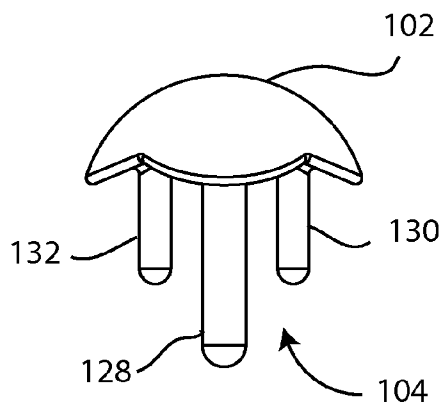

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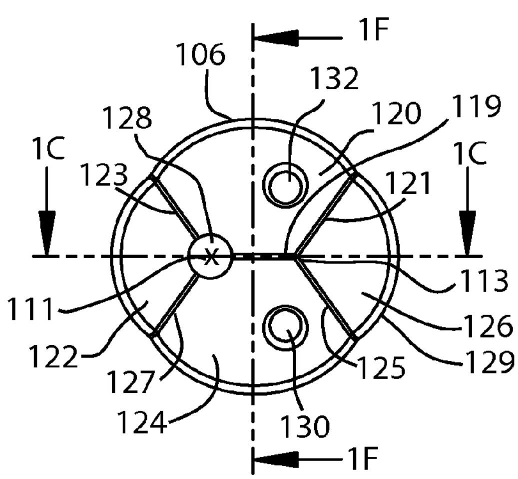

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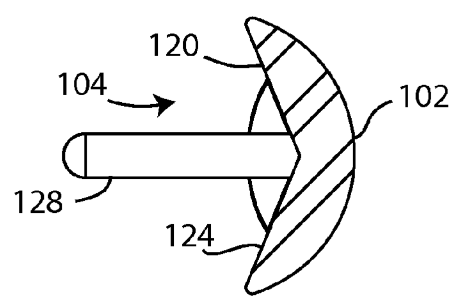

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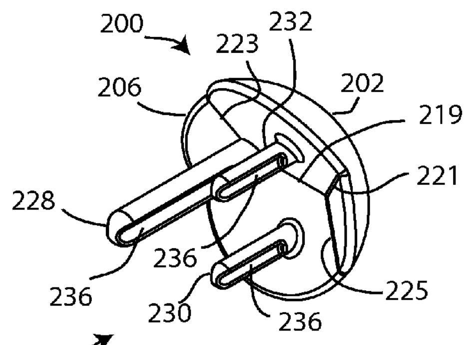

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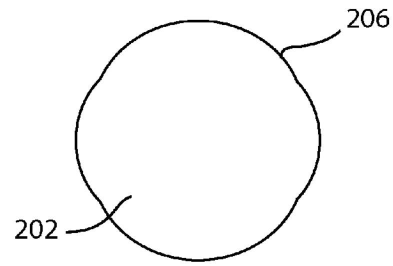

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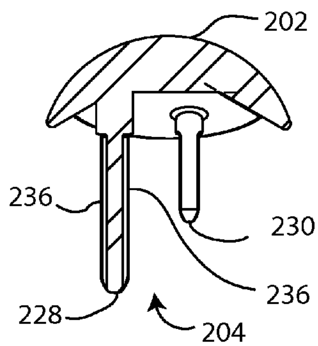

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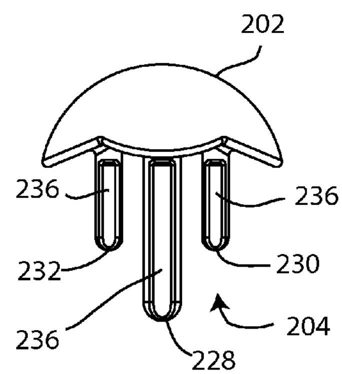

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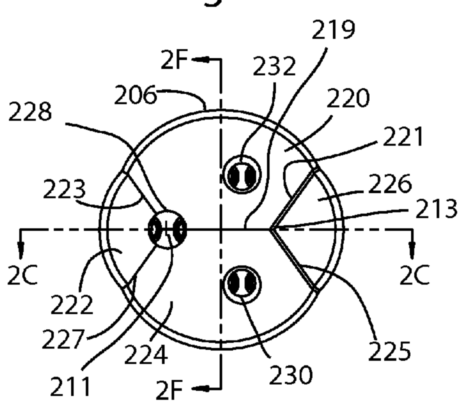

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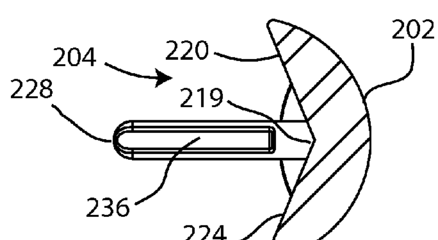

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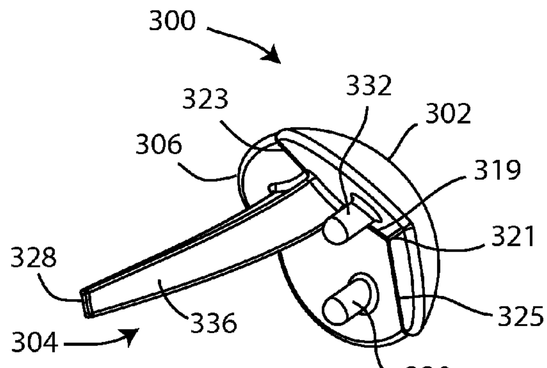
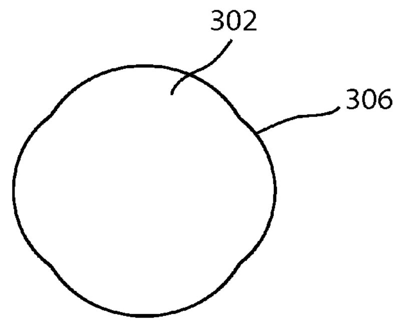


Fig. 3A



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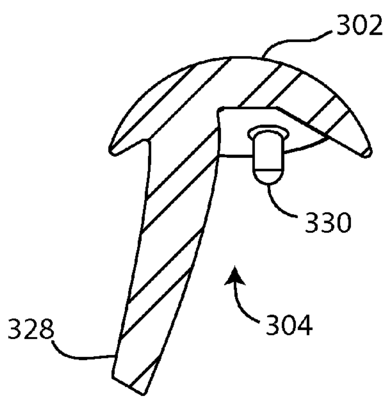

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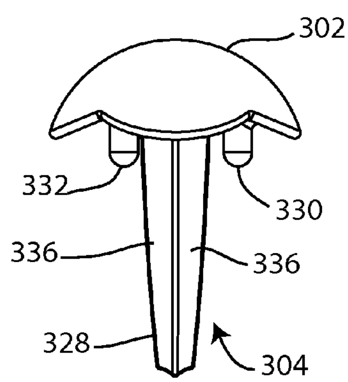

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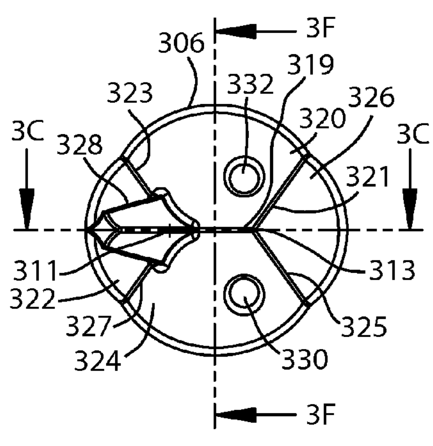

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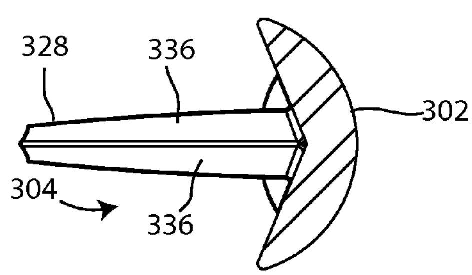

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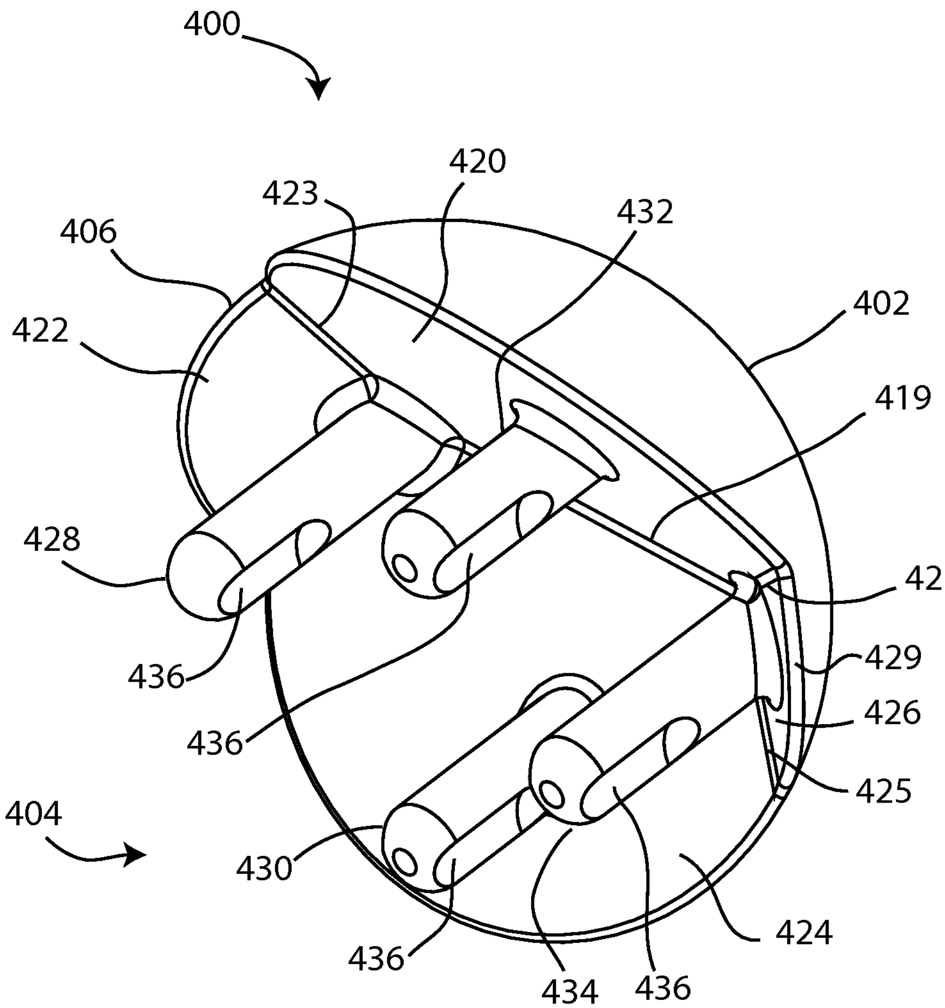
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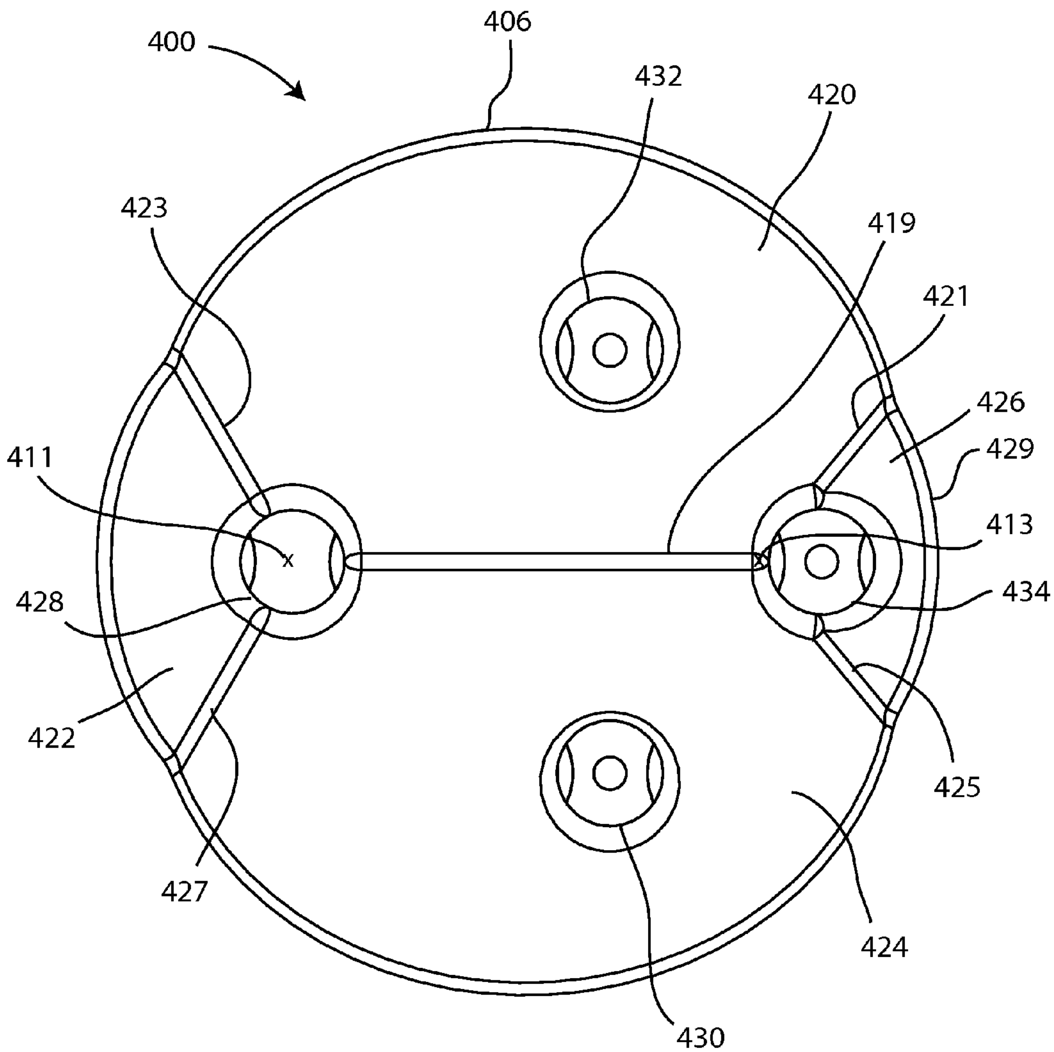
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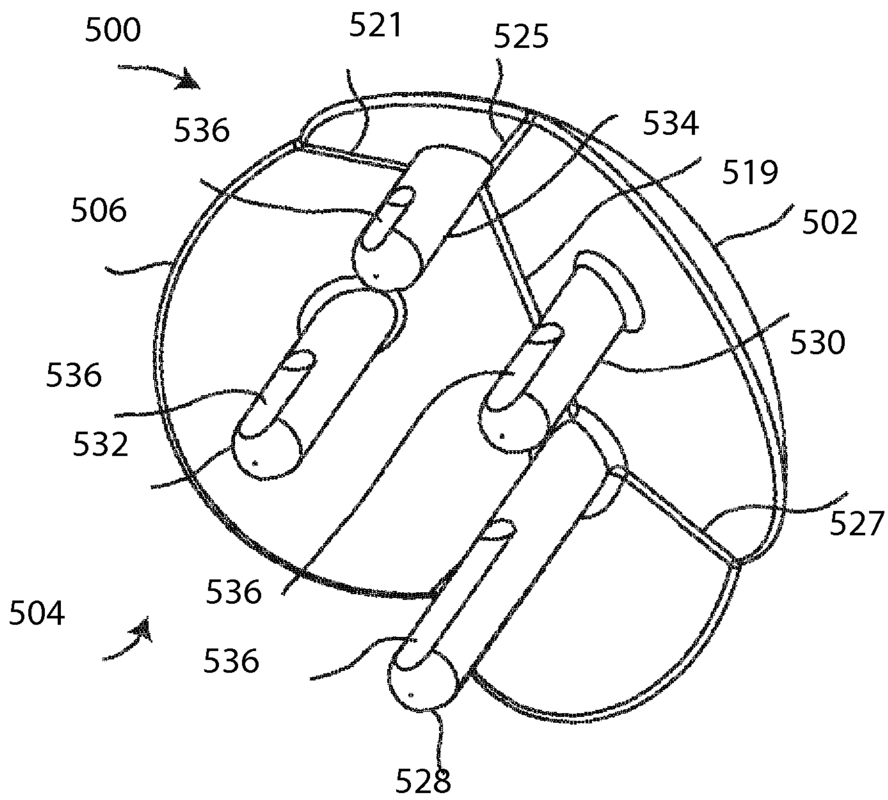

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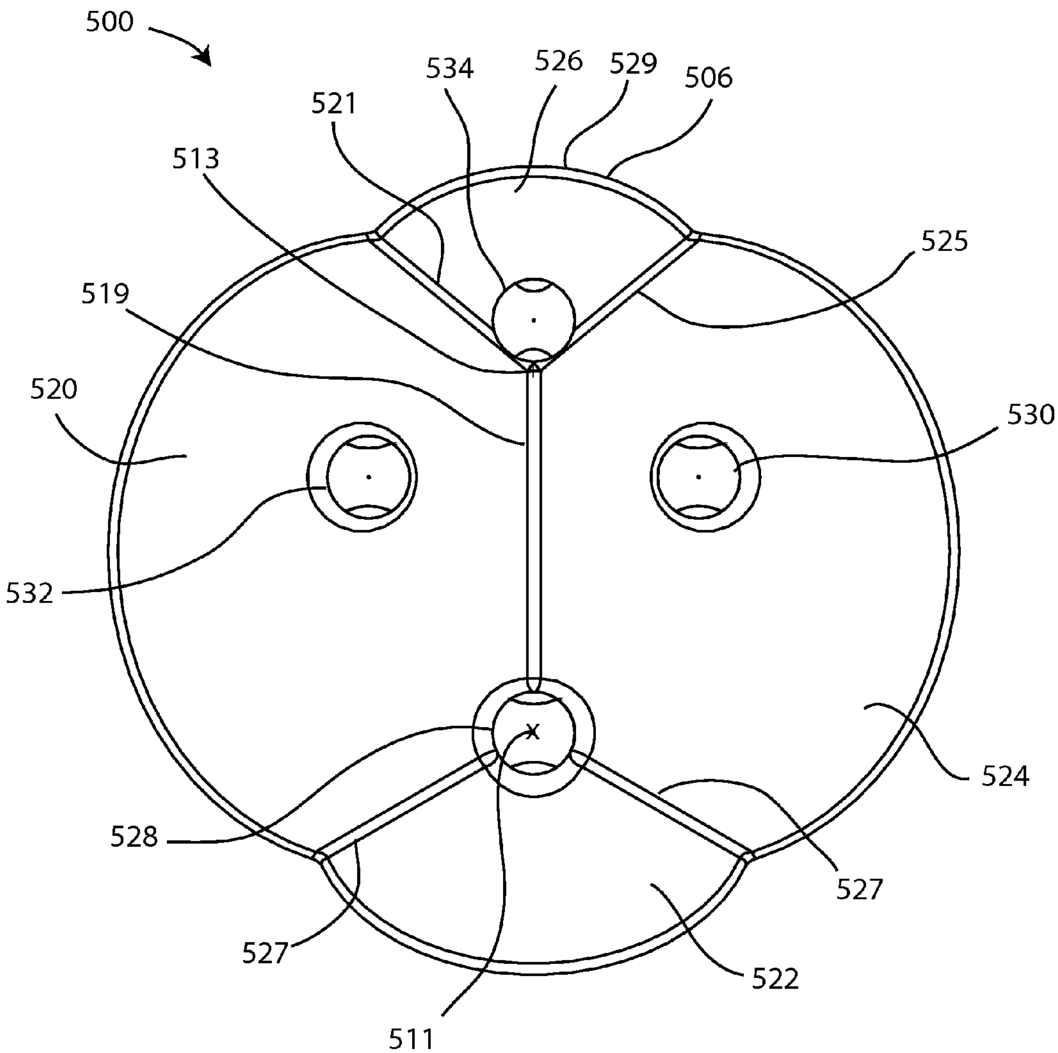

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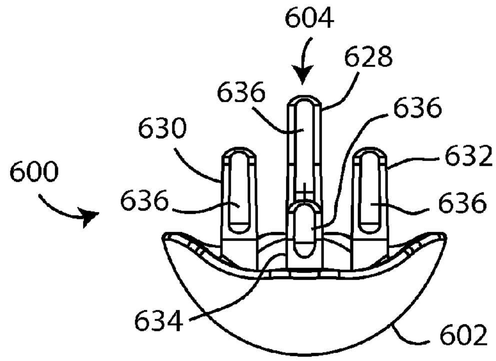

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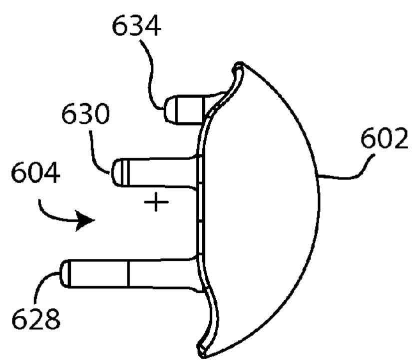

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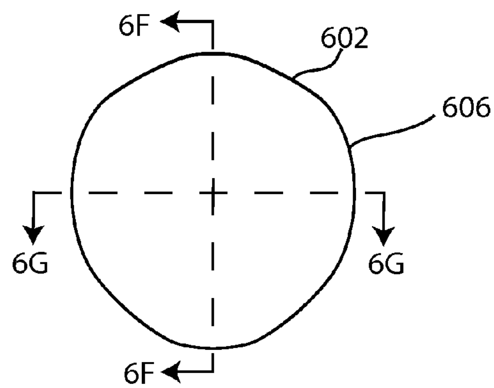

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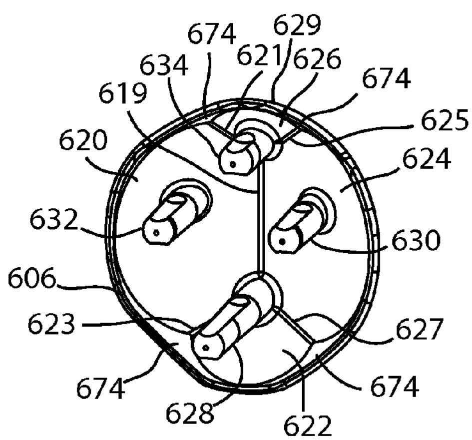

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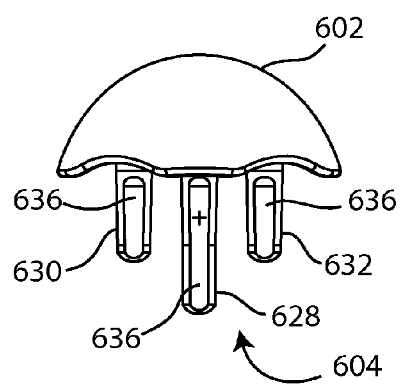

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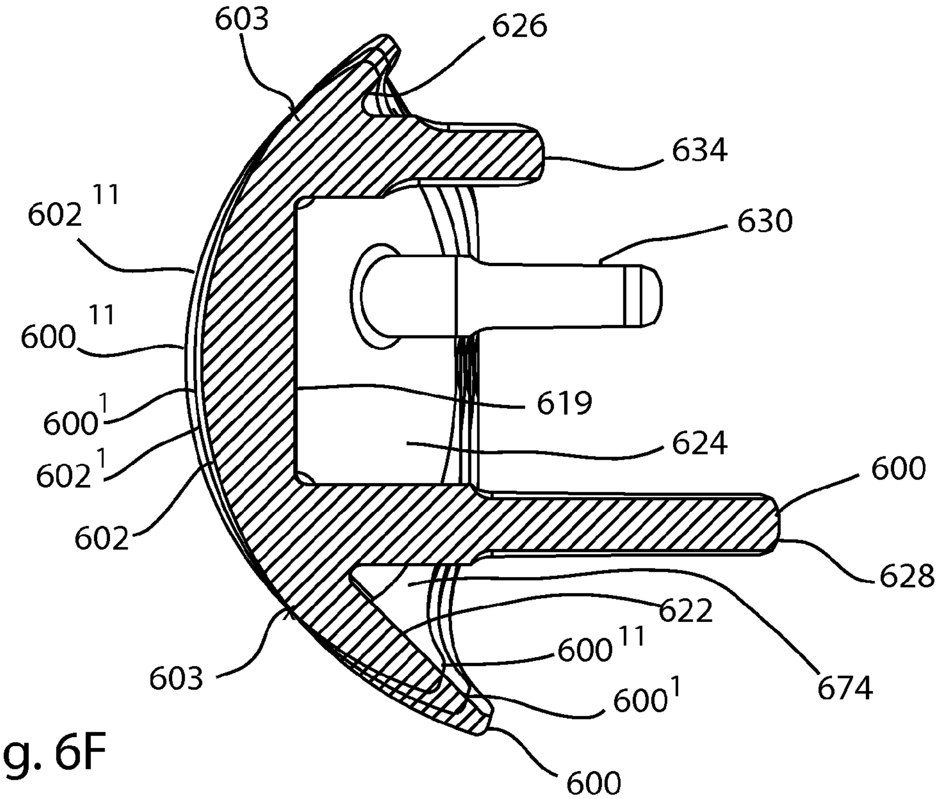
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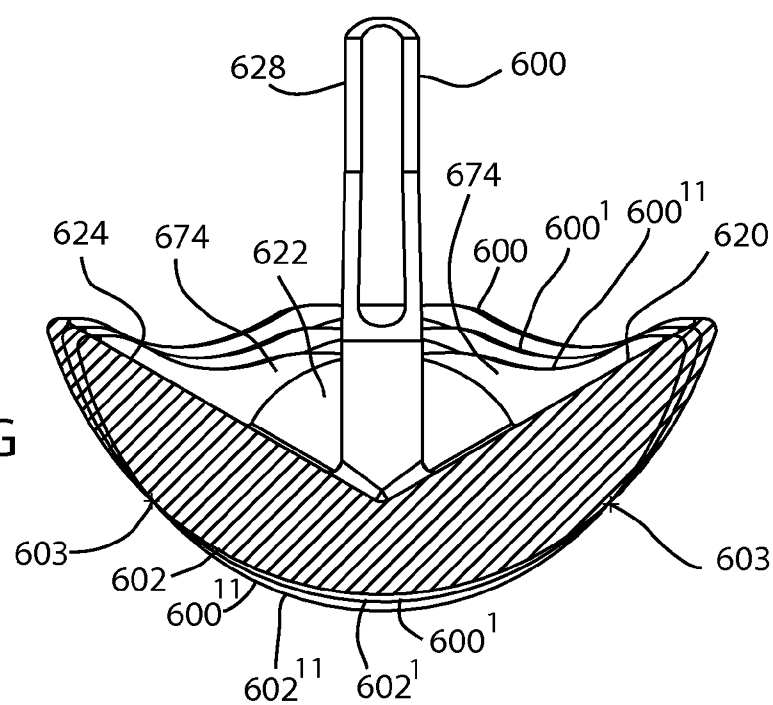
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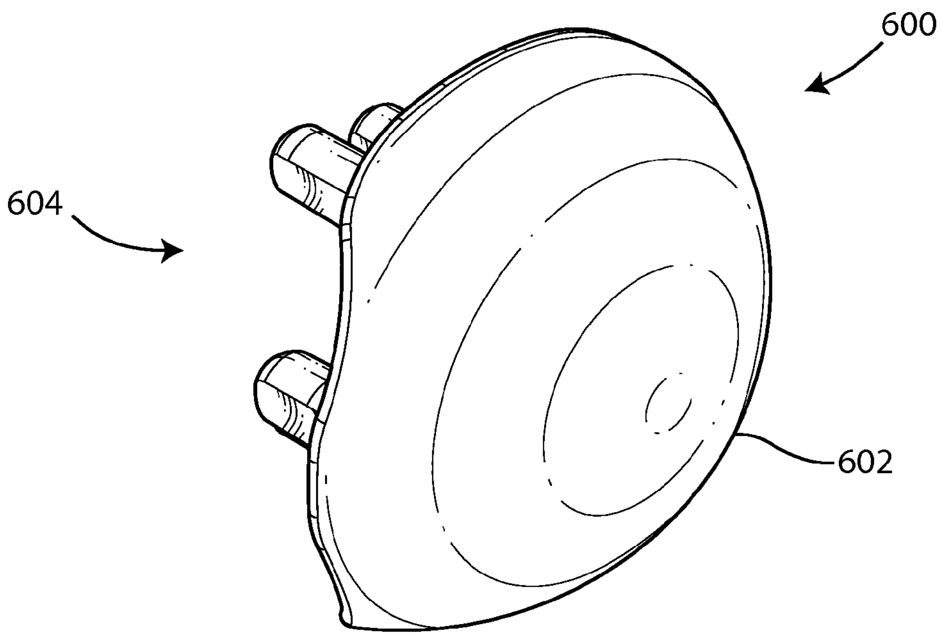

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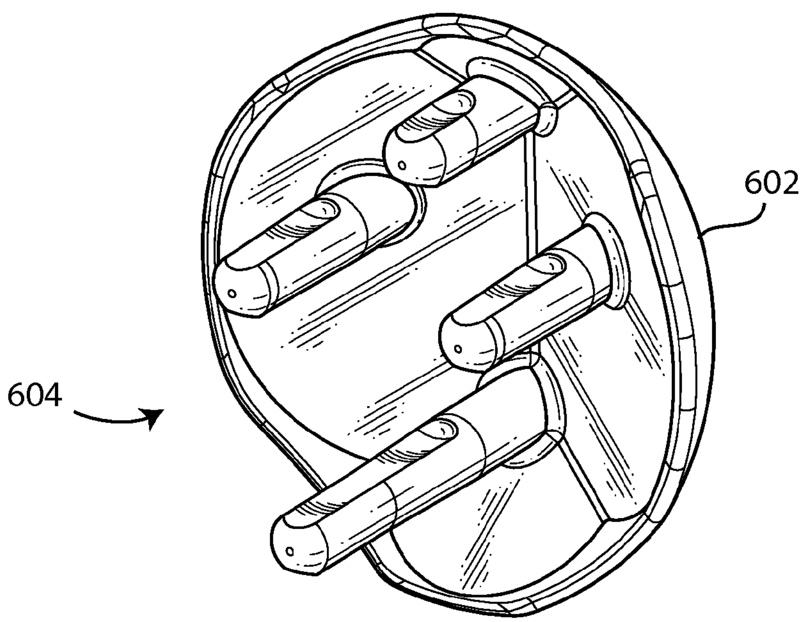

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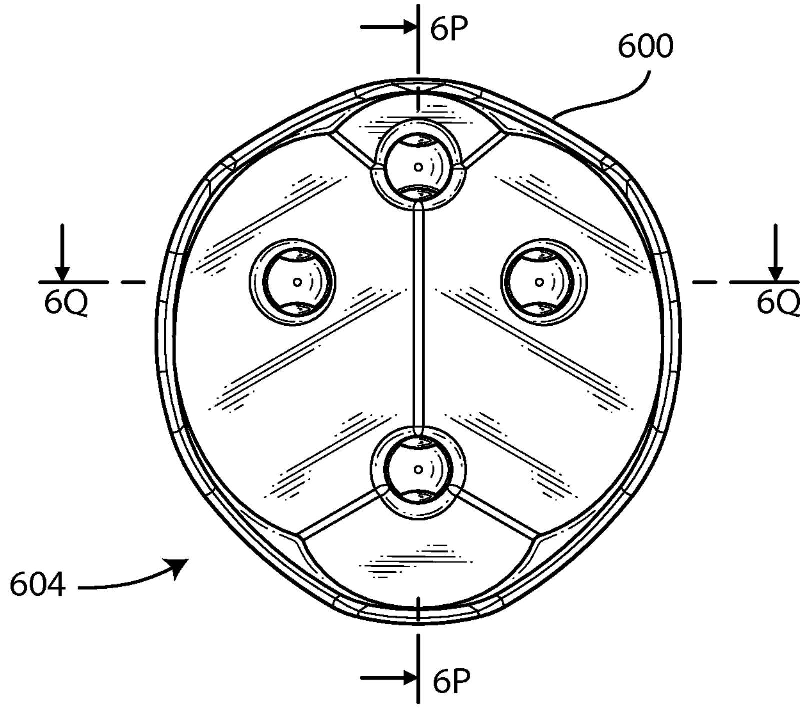

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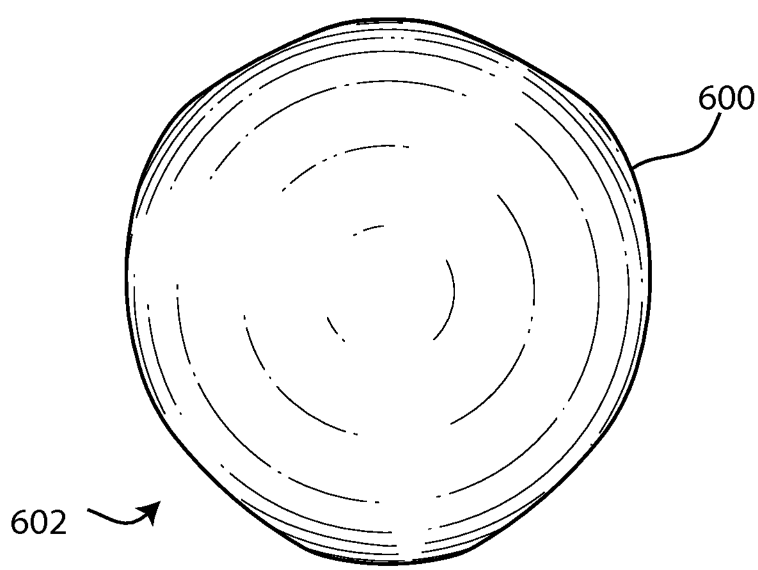

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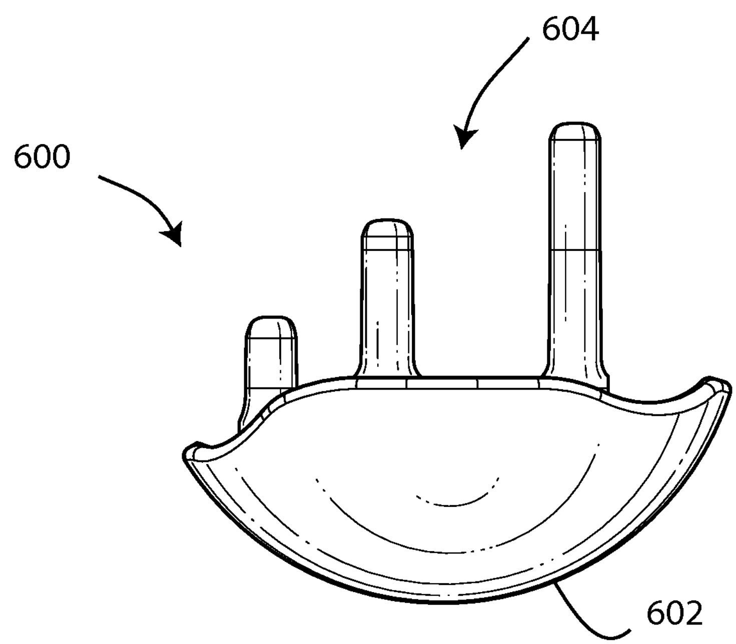

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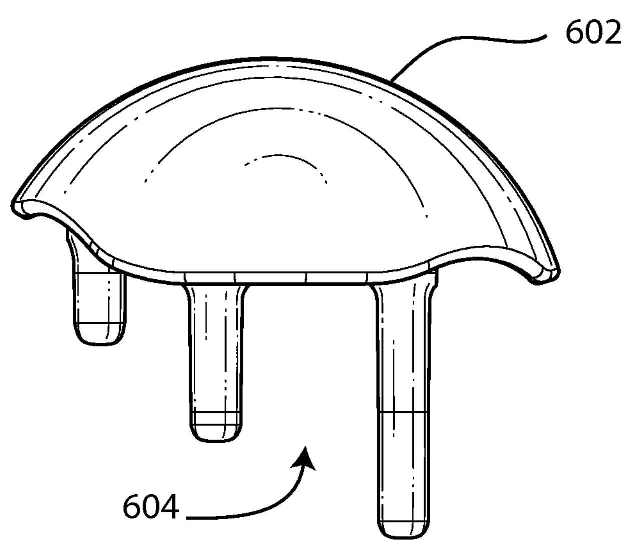

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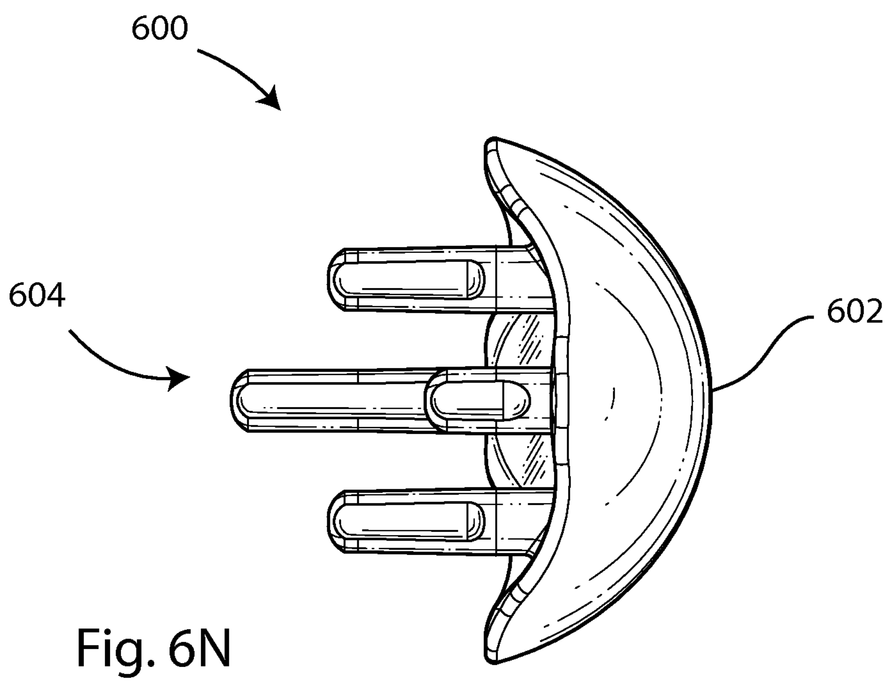

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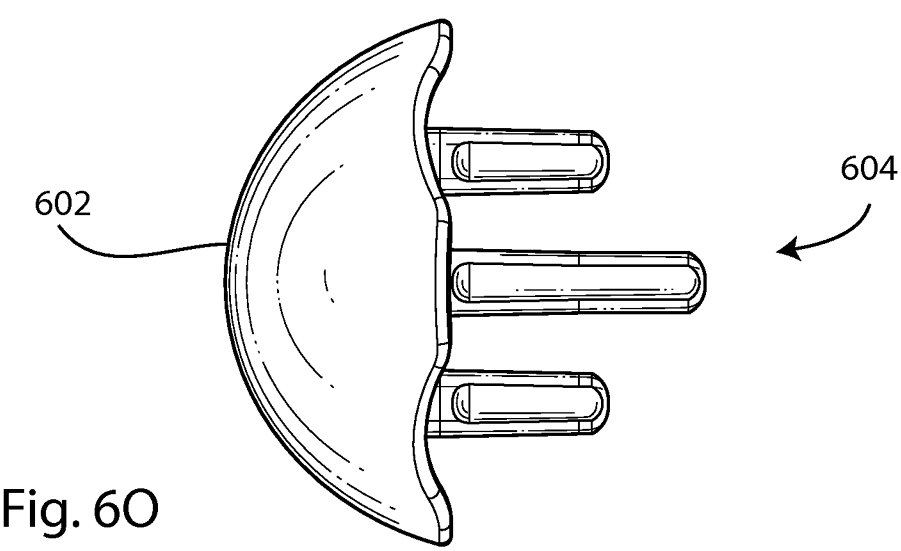

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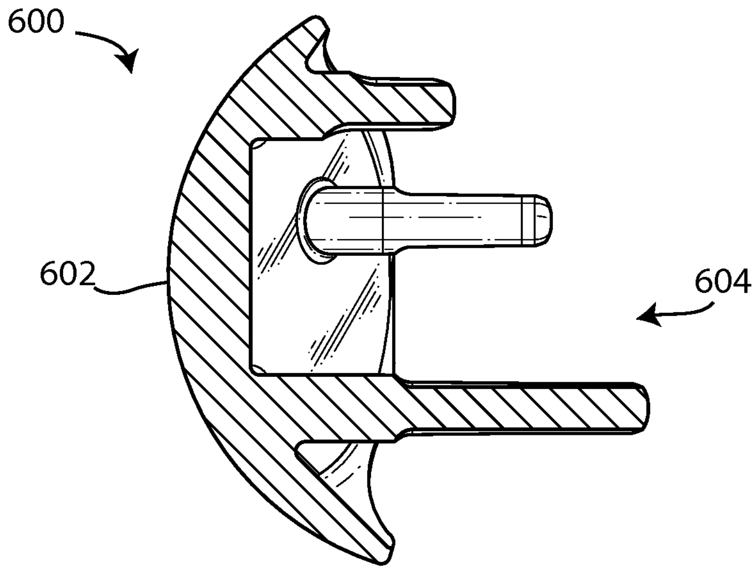

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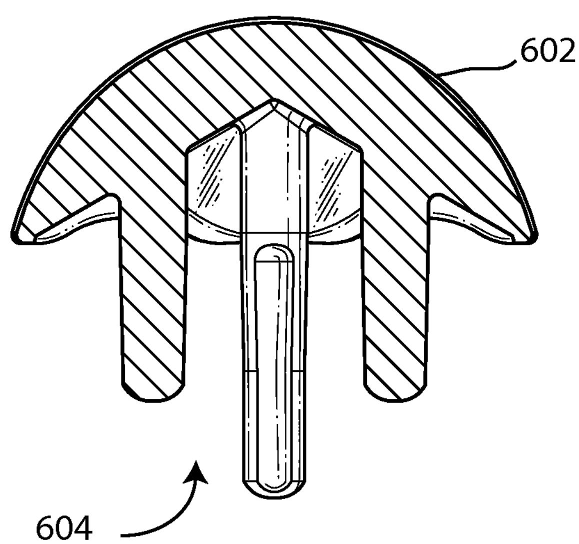

Fig. 6Q

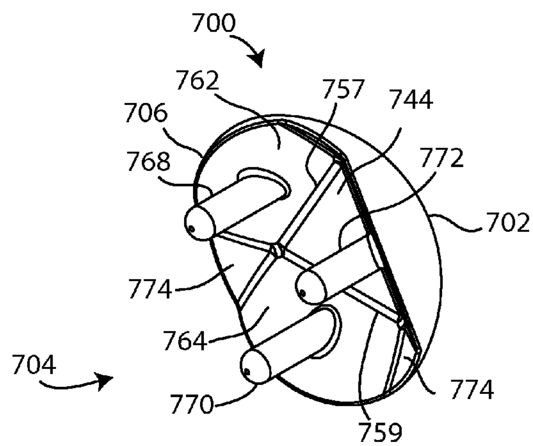

Fig. 7A

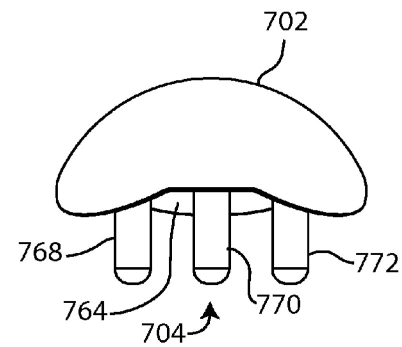

Fig. 7B

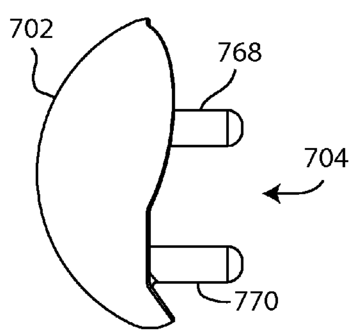

Fig. 7C

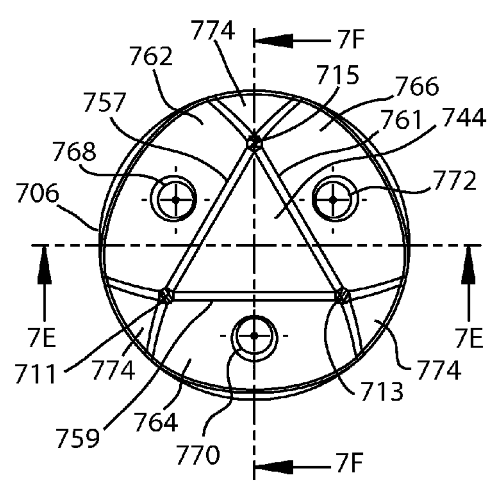

Fig. 7D

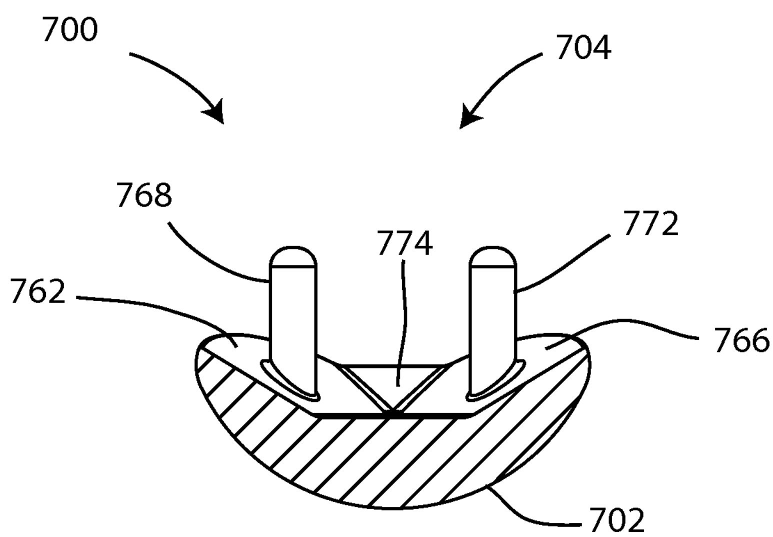

Fig. 7E

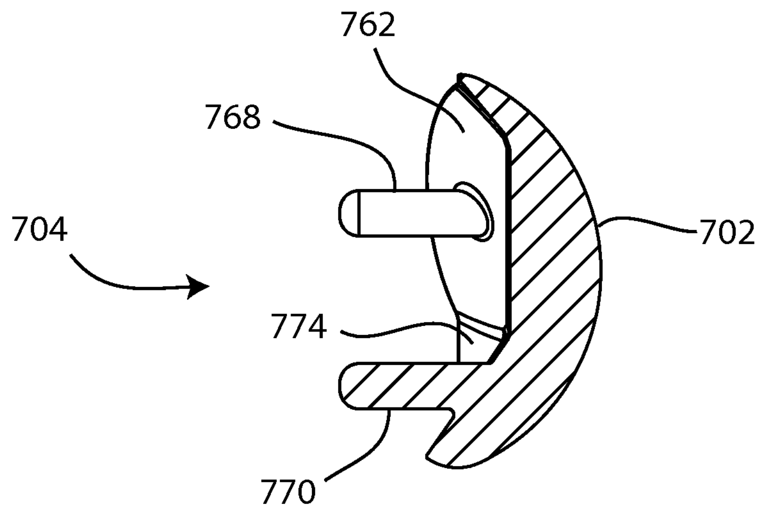

Fig. 7F

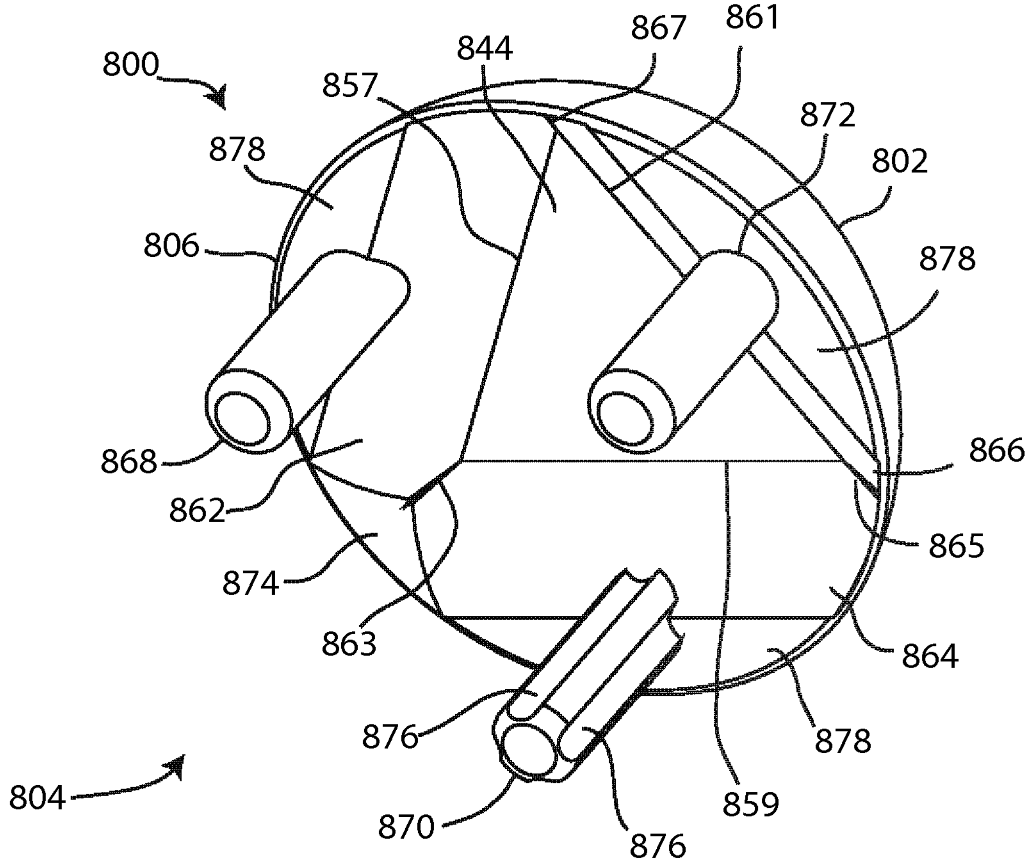
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Fig. 8A

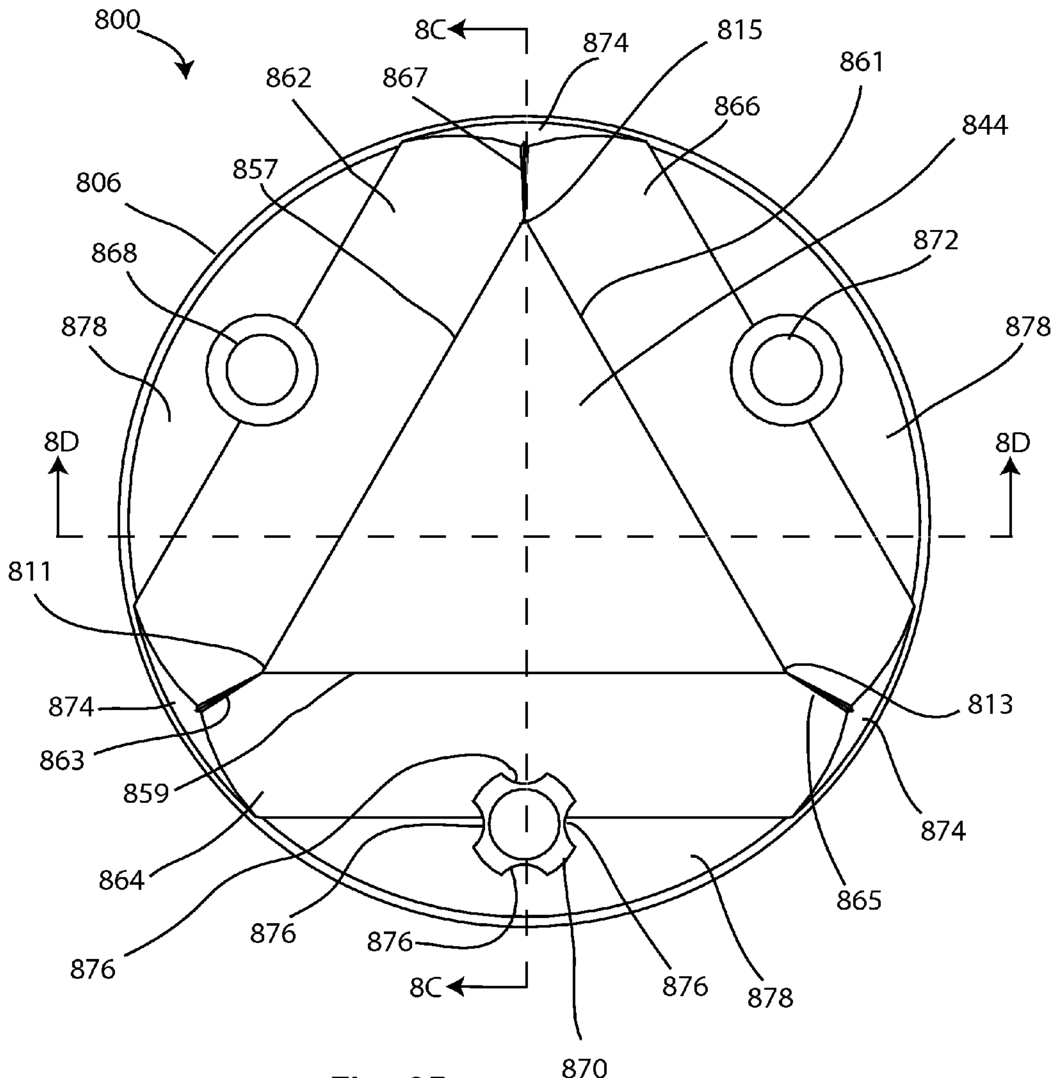
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Fig. 8B

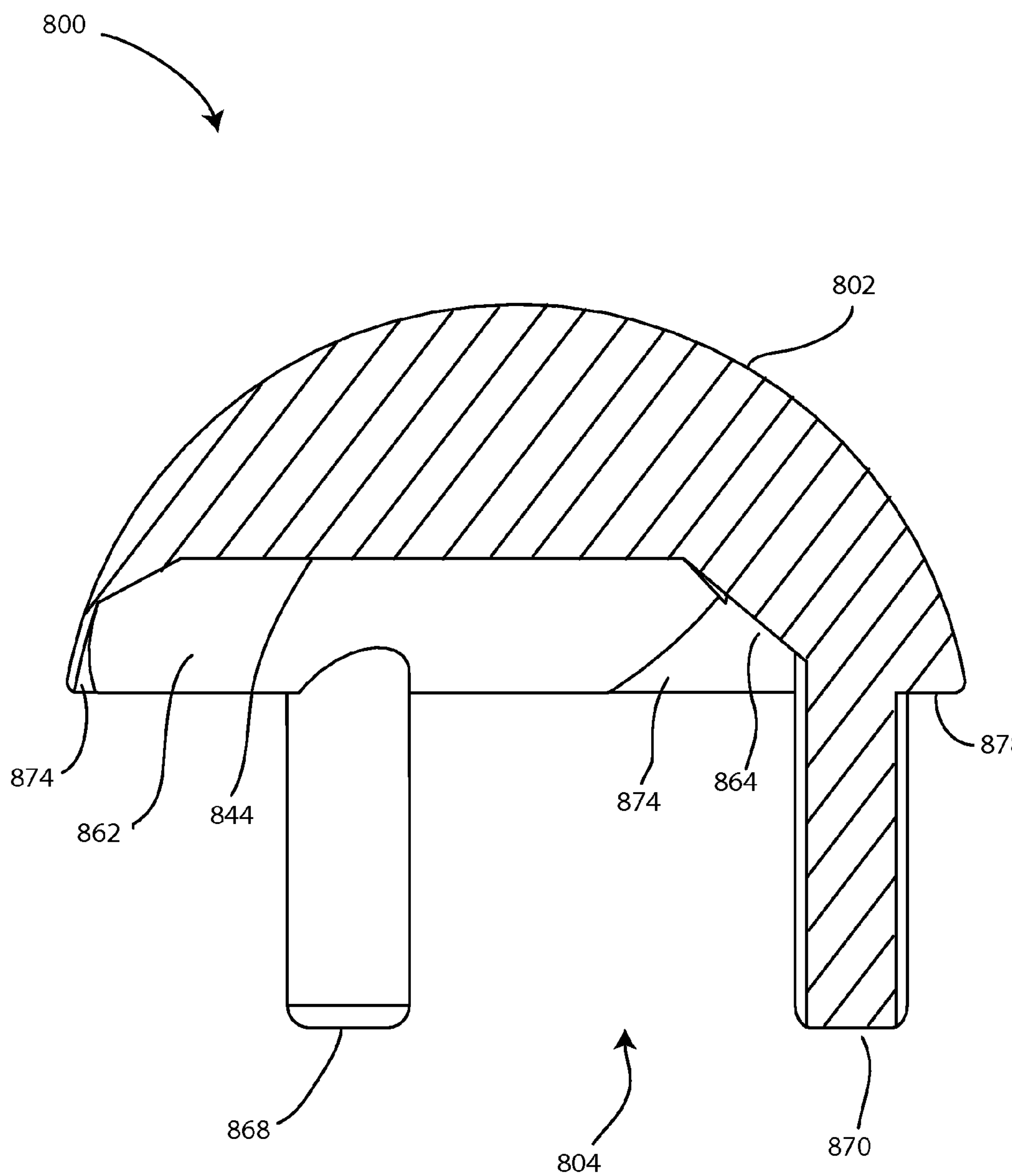

Fig. 8C

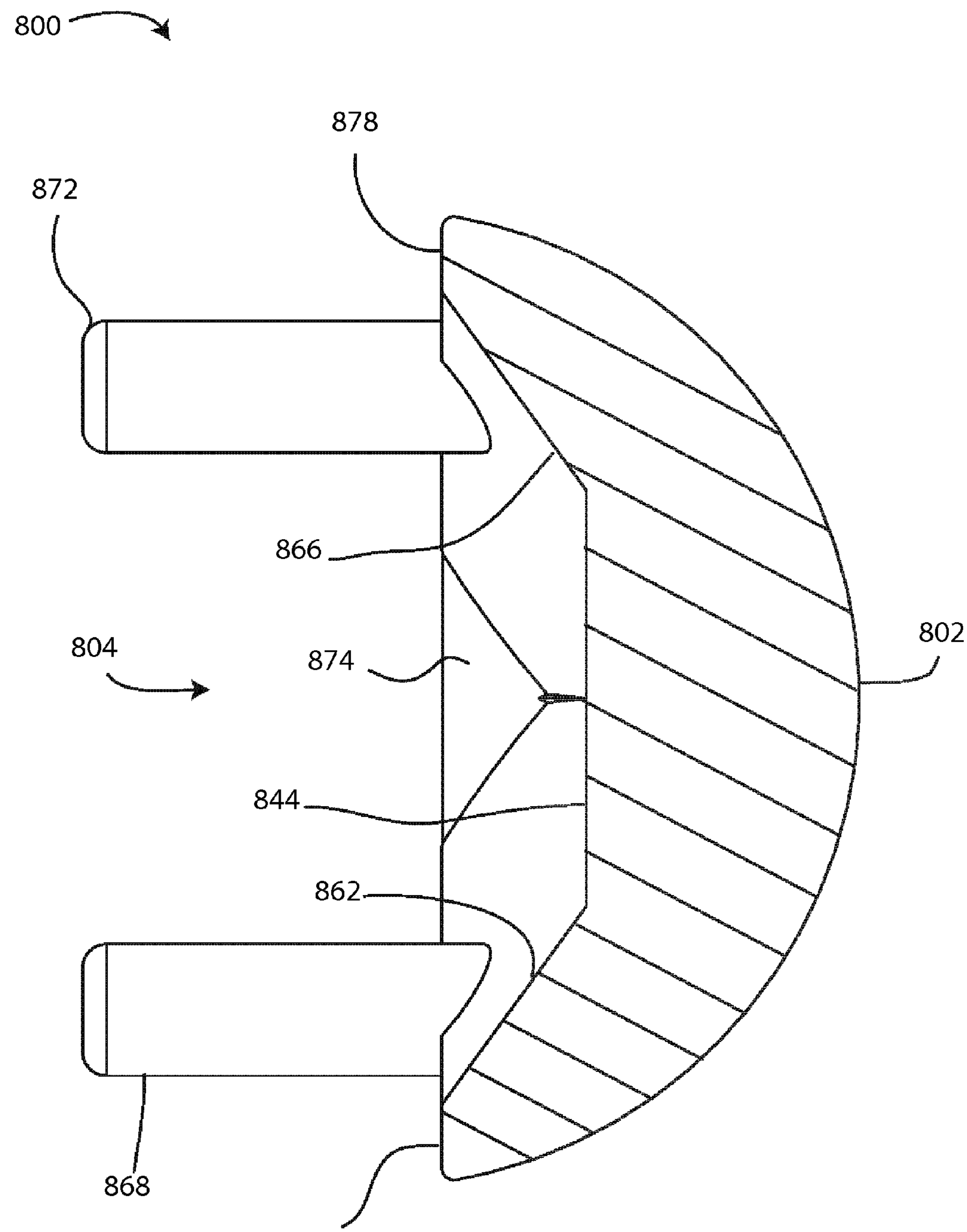

Fig. 8D

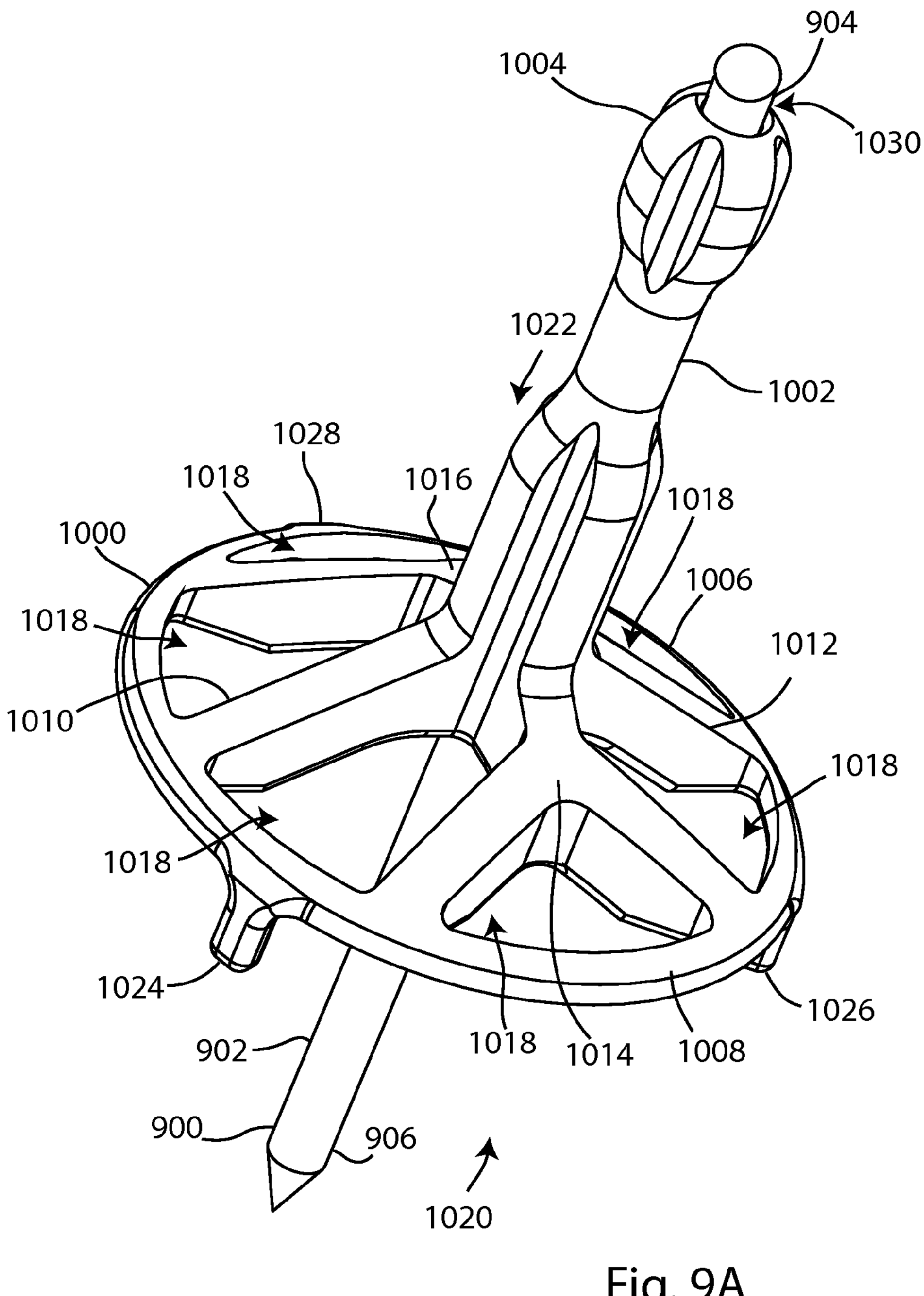
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Fig. 9A

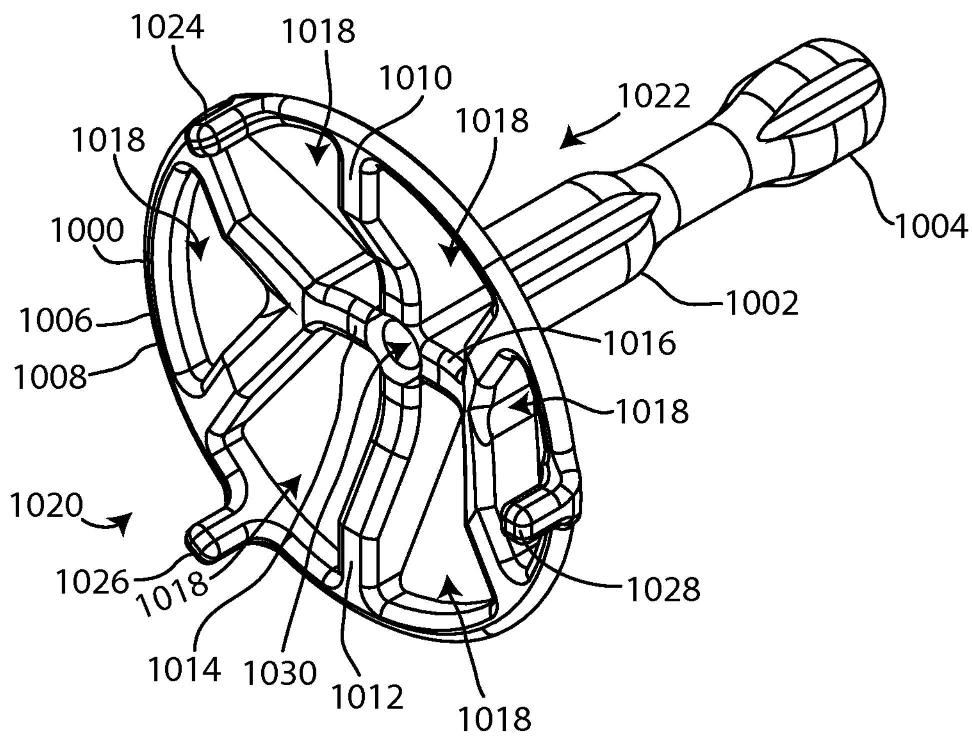
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Fig. 9B

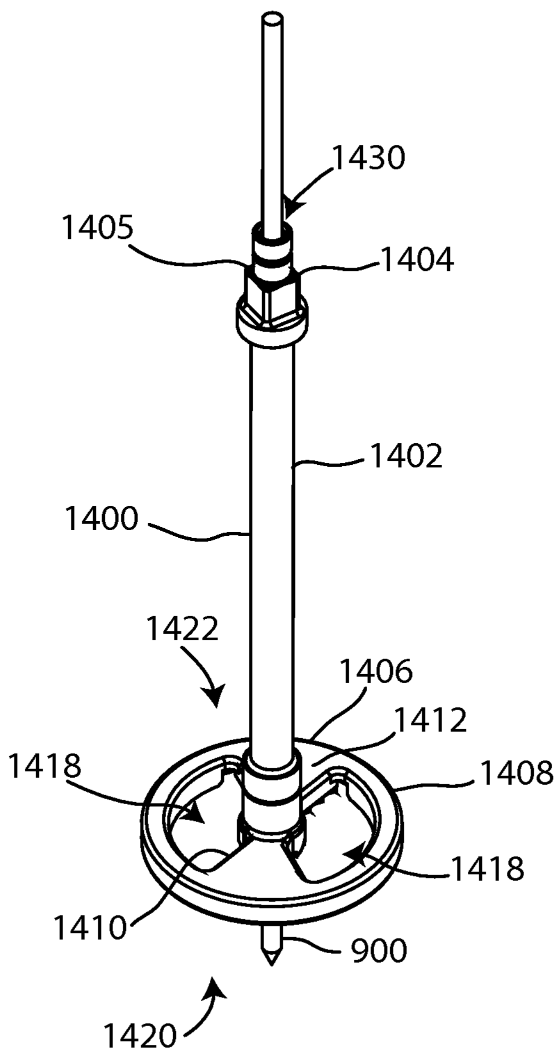
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Fig. 10A

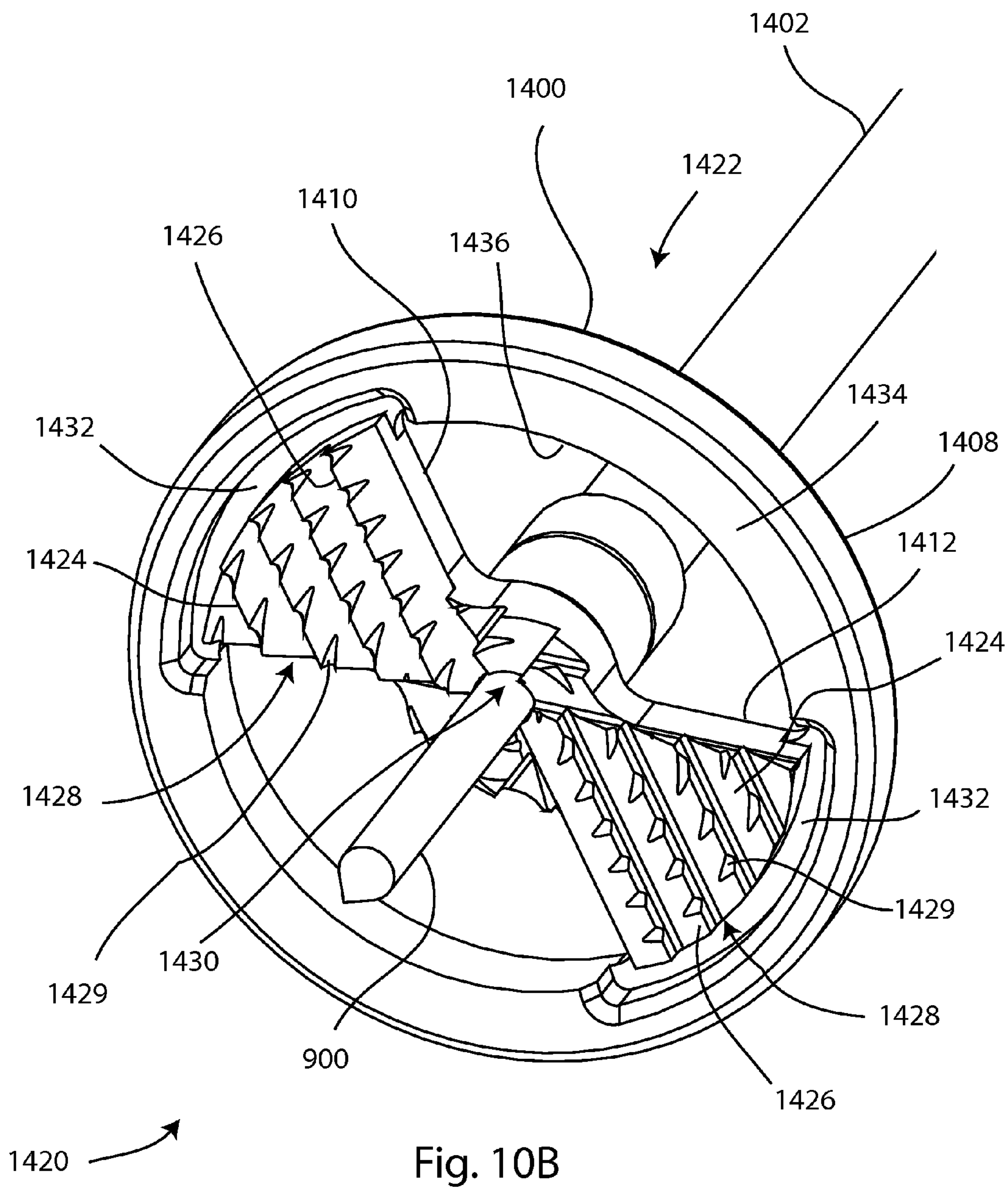
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Fig. 10B

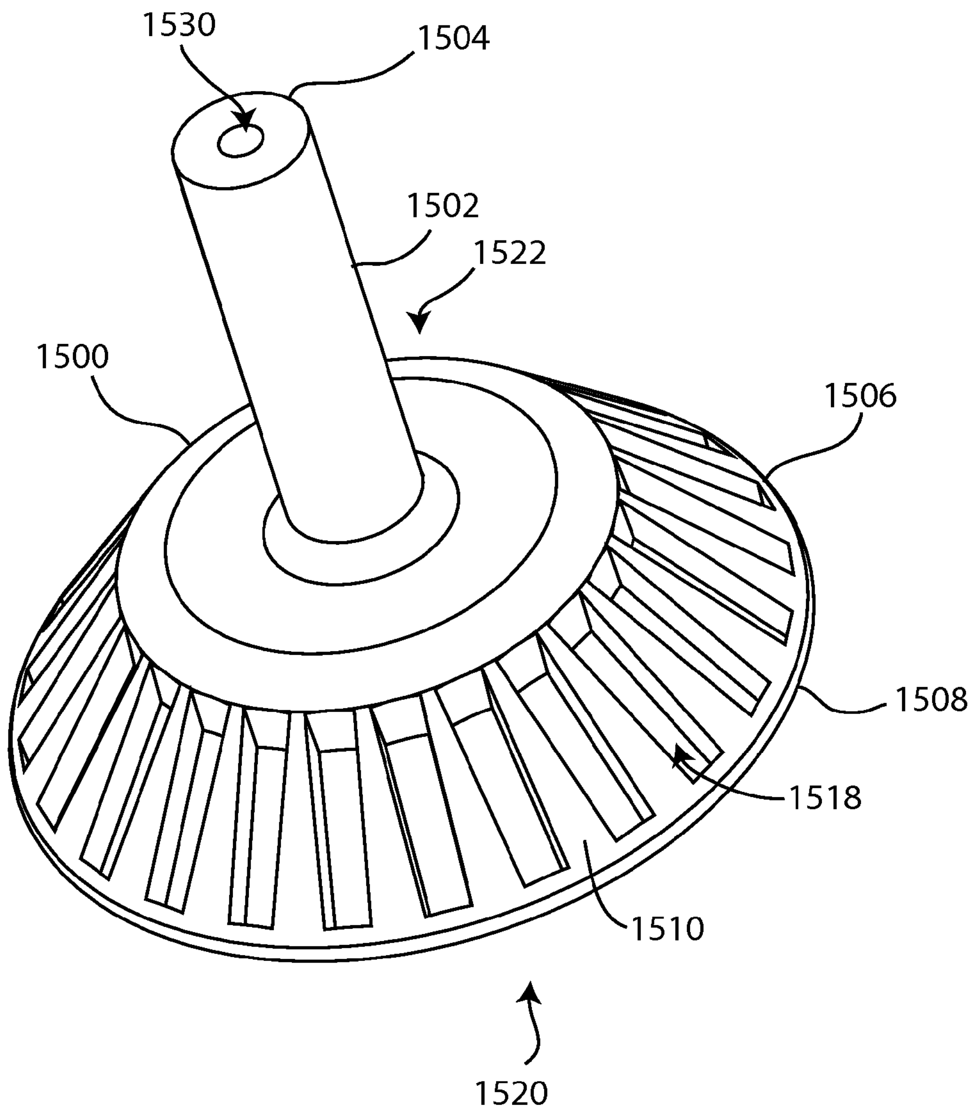

Fig. 11A

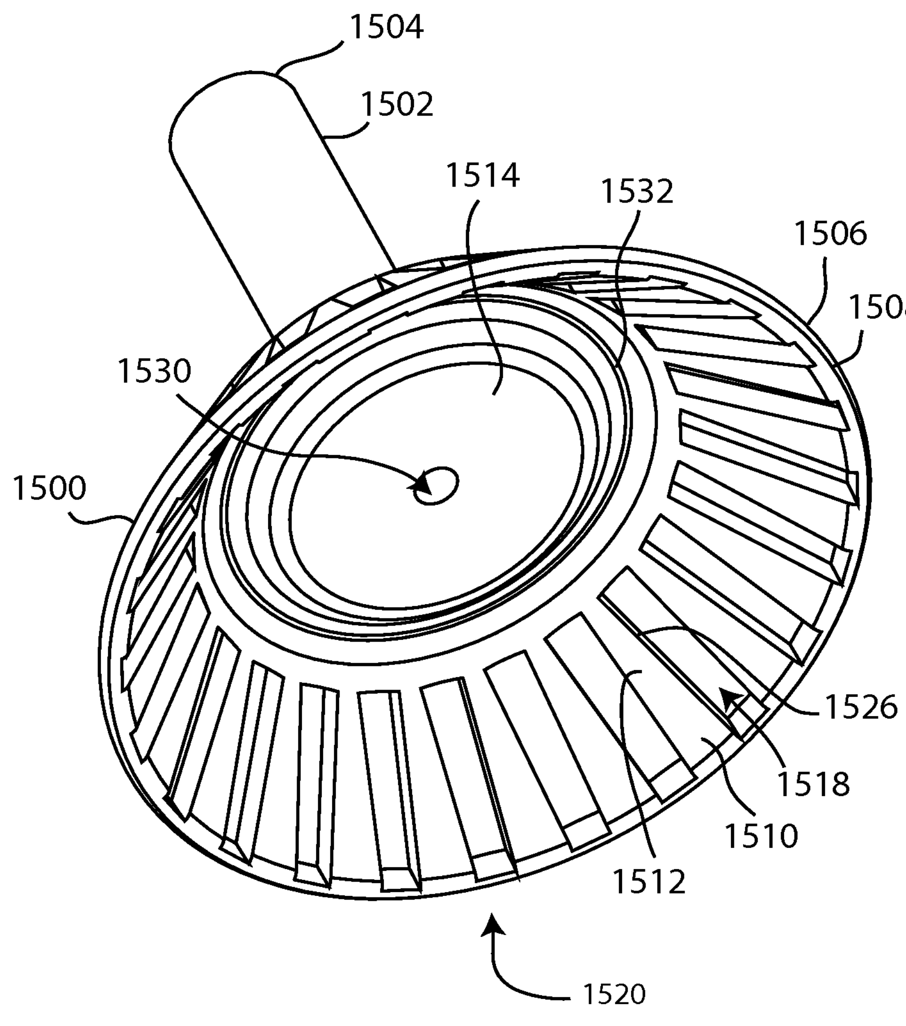
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Fig. 11B

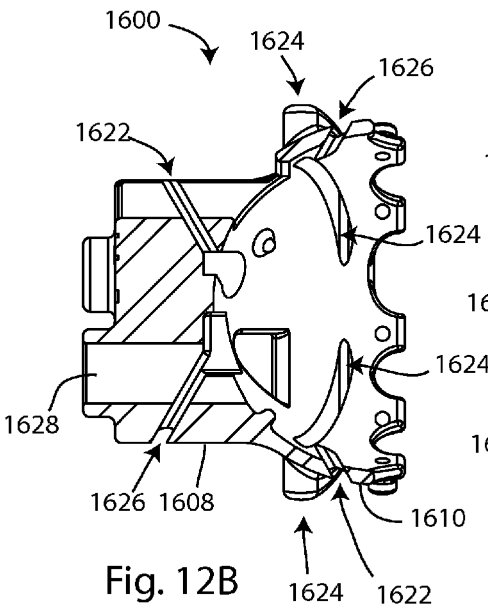

Fig. 12B

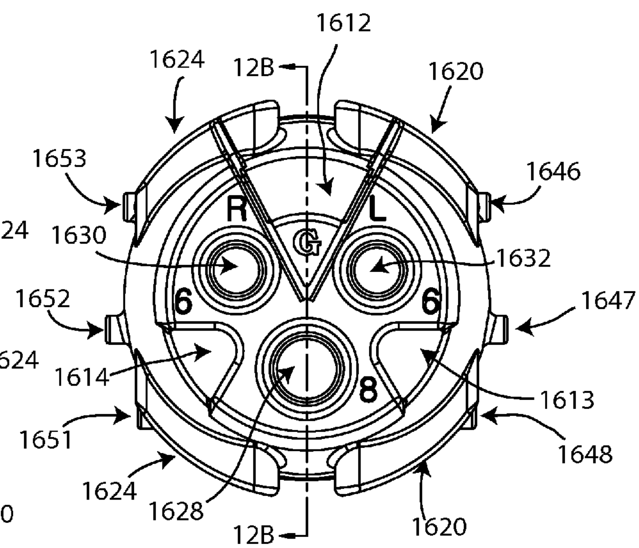

Fig. 12A

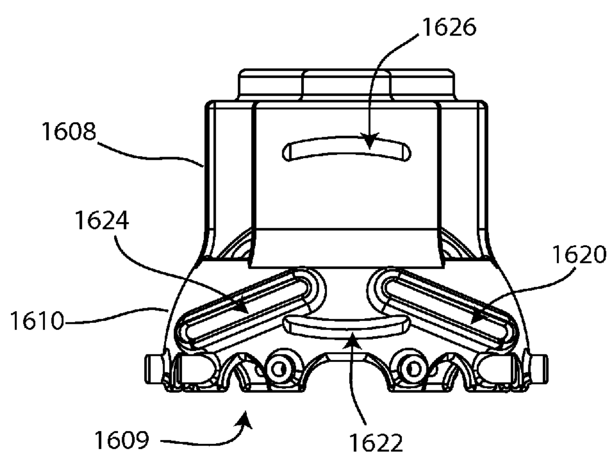

Fig. 12C

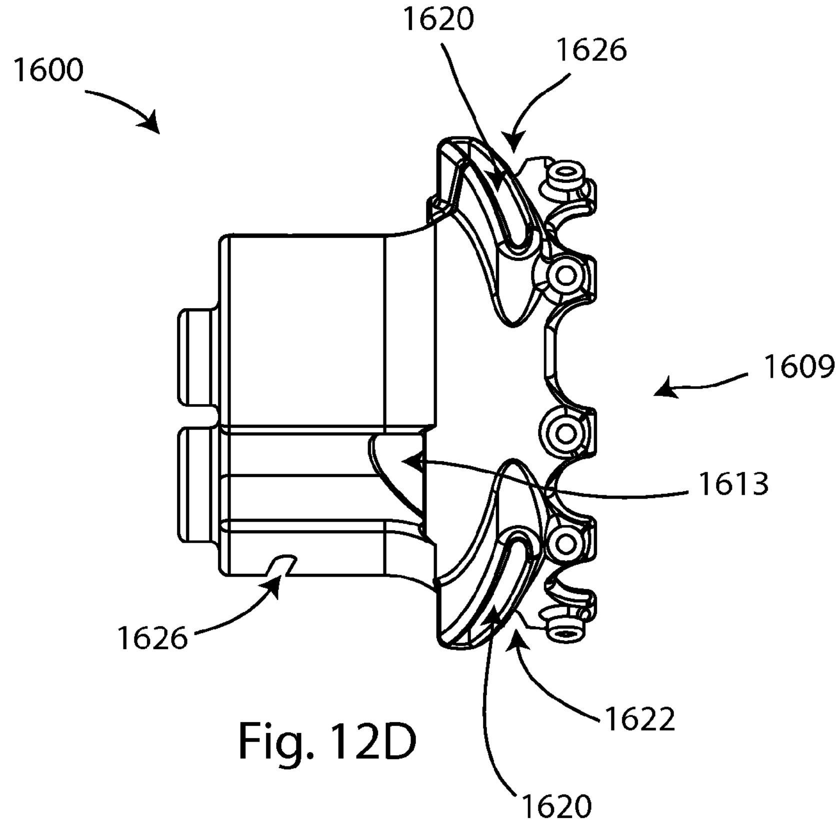

Fig. 12D

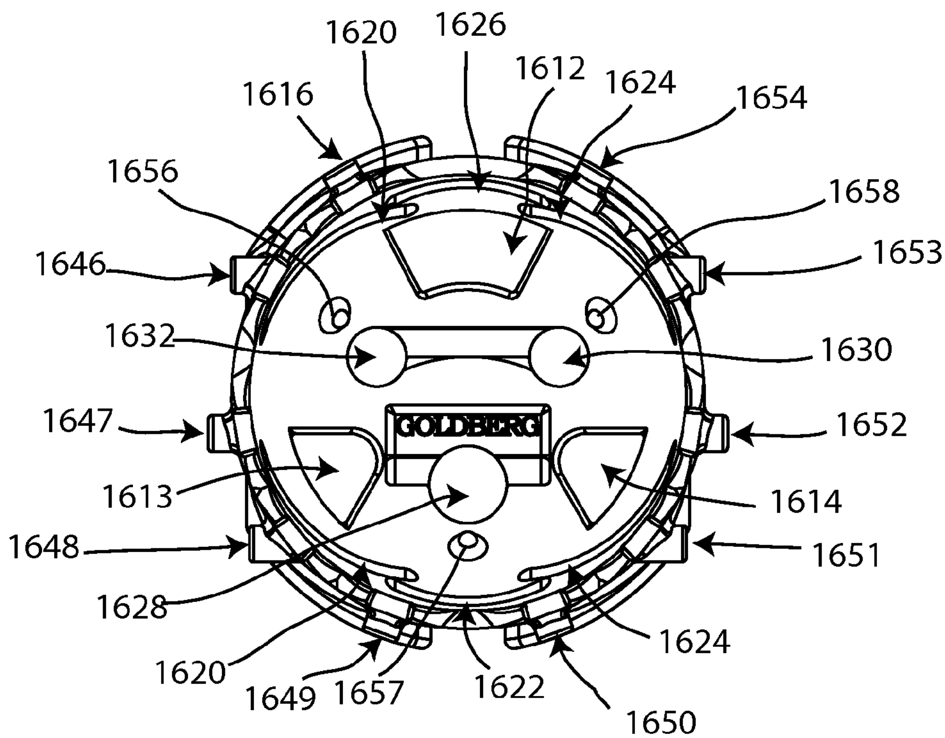

Fig. 12E

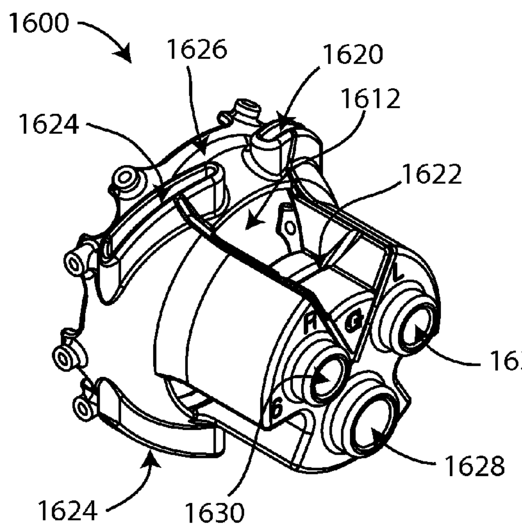

Fig. 12F

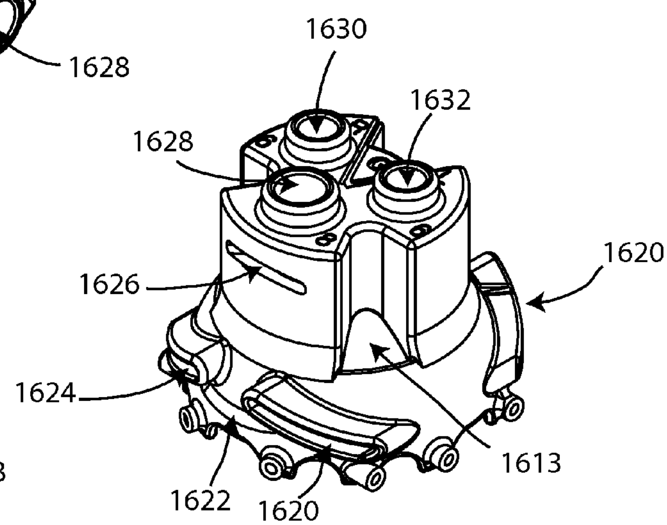

Fig. 12G

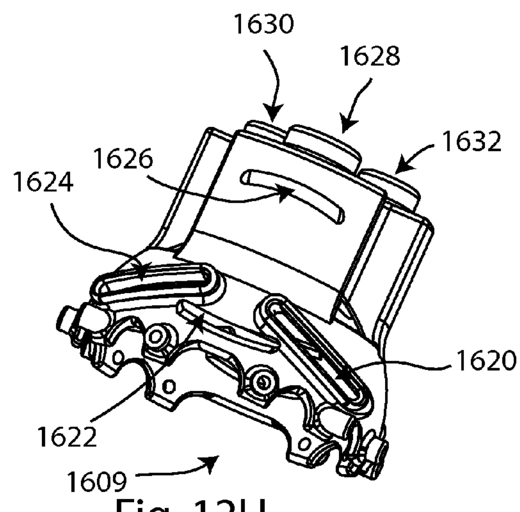

Fig. 12H

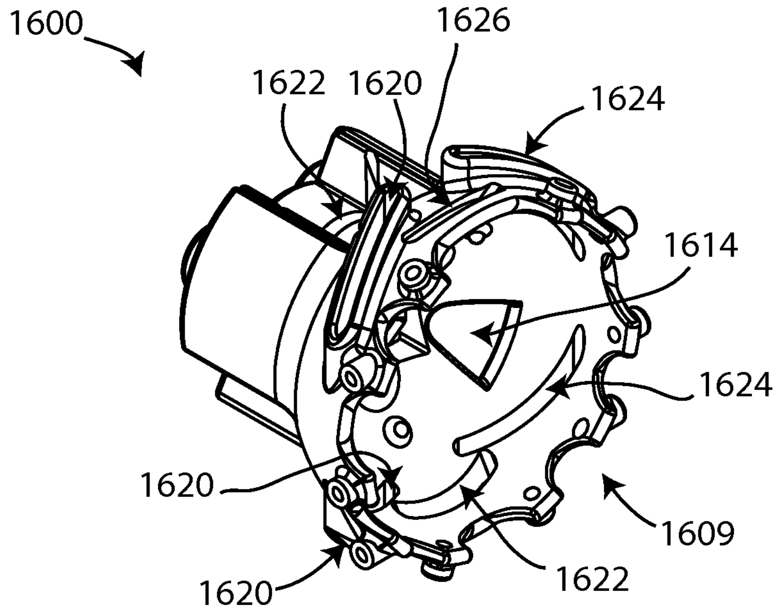

Fig. 12I

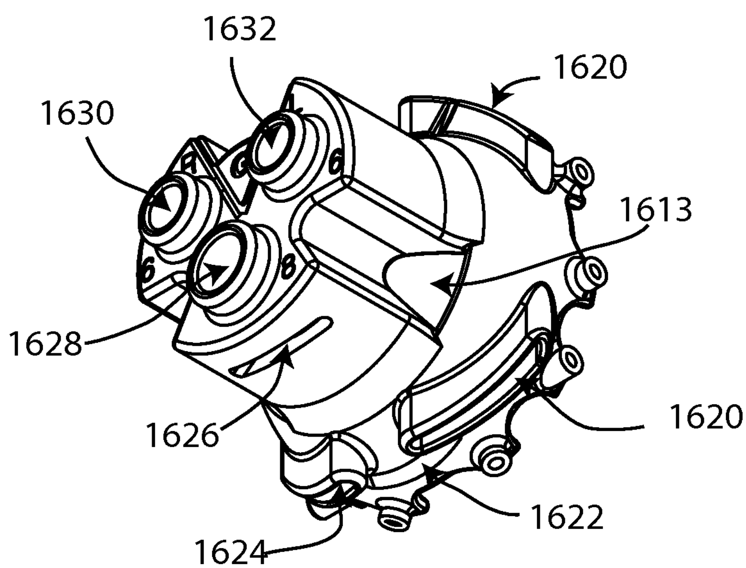

Fig. 12J

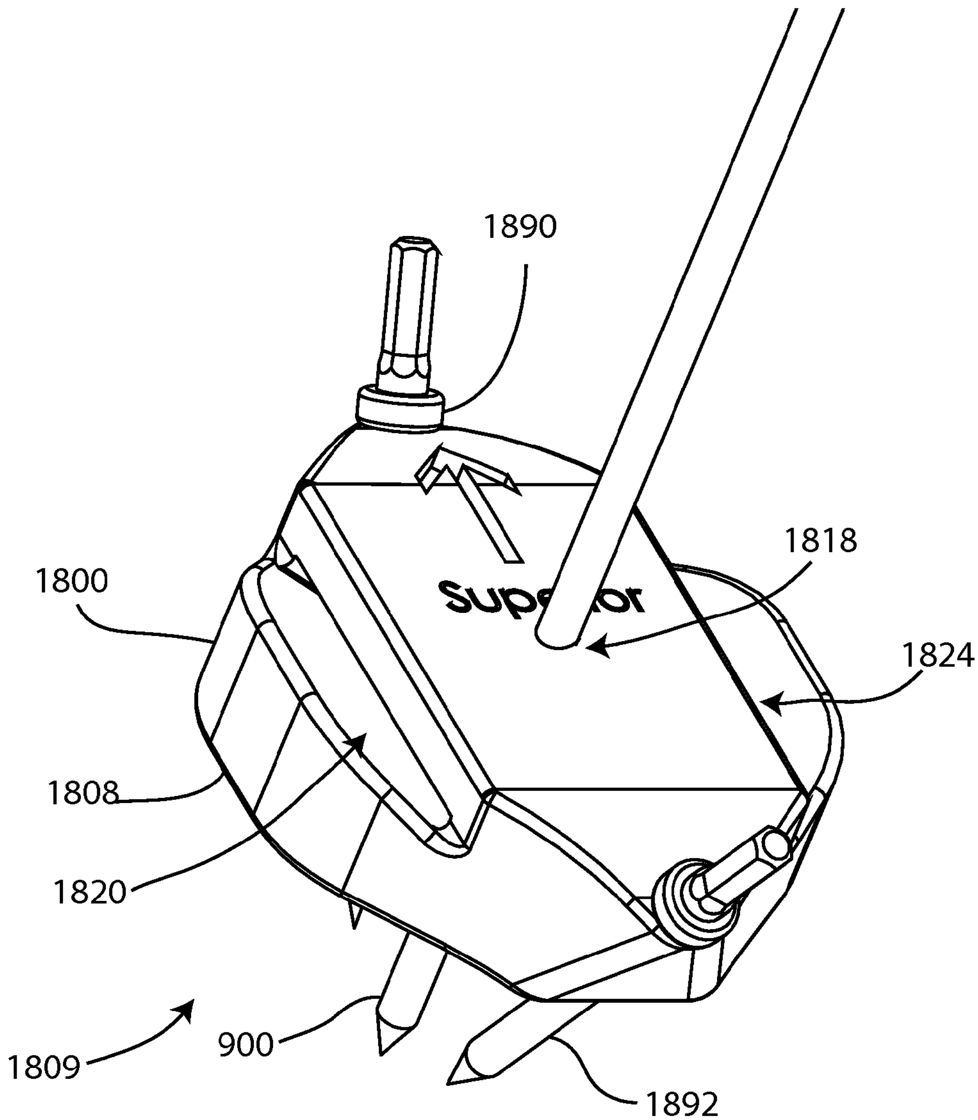

Fig. 13A

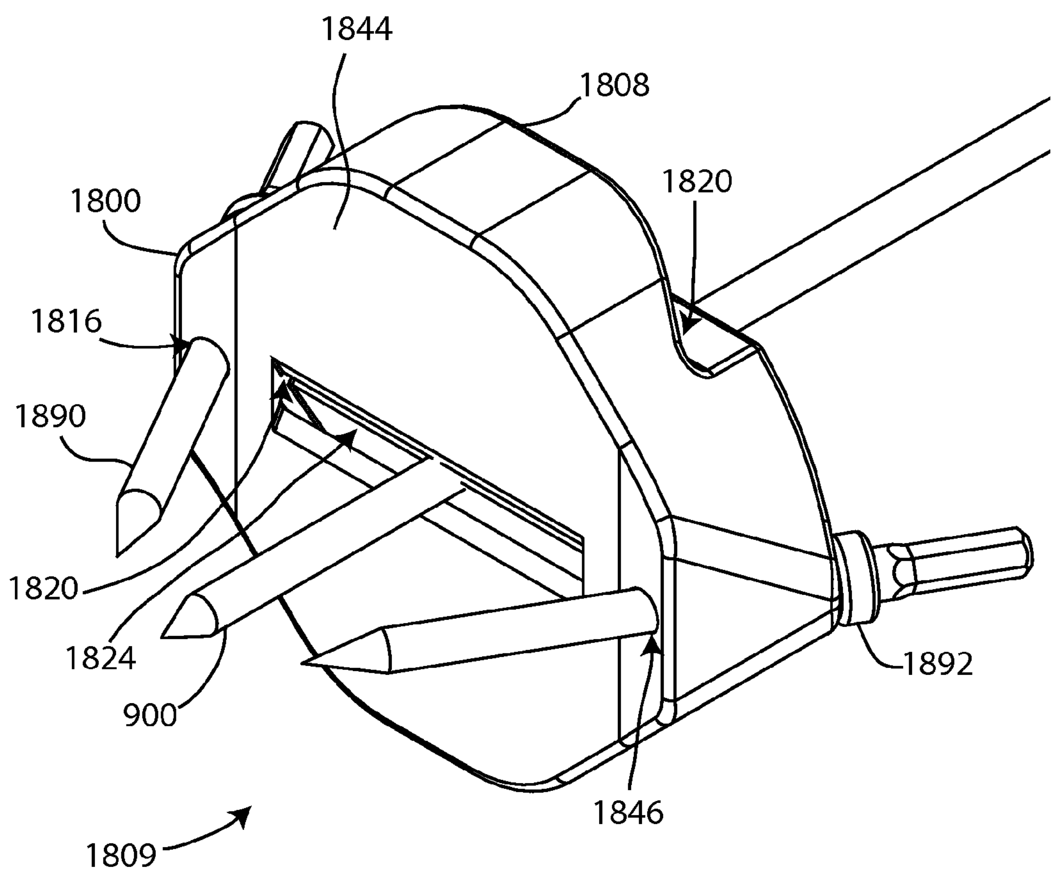

Fig. 13B

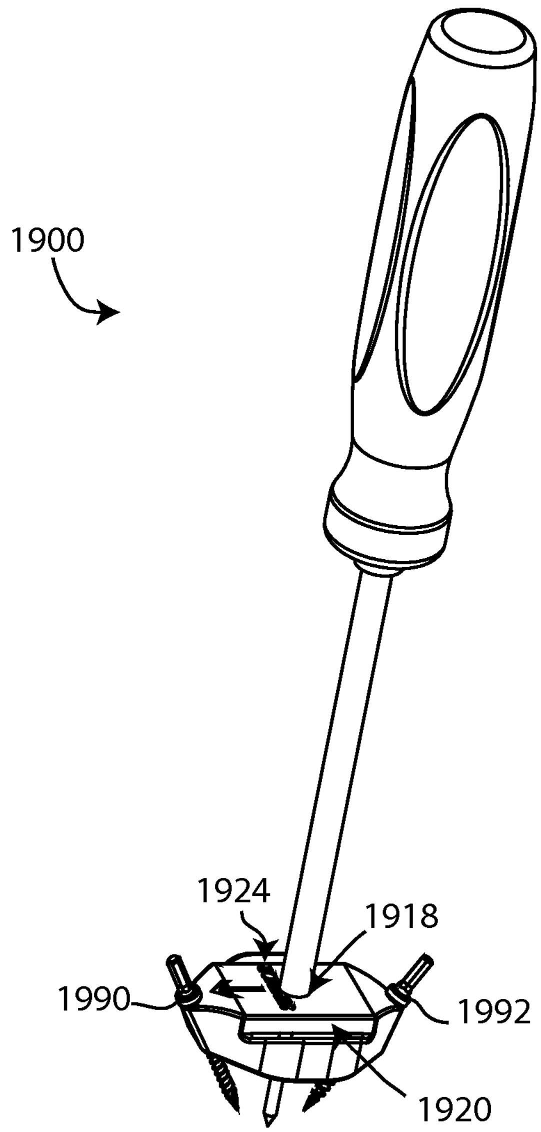

Fig. 14

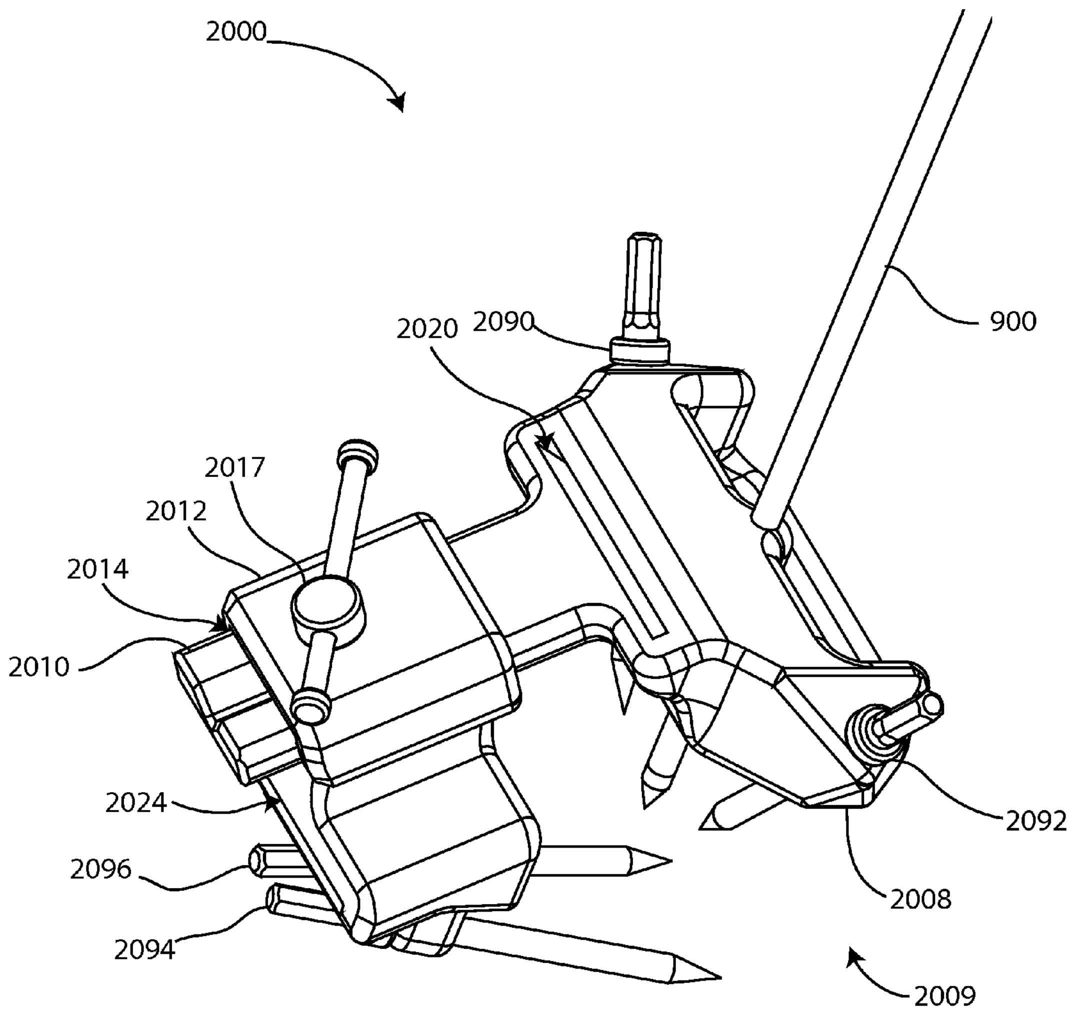
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Fig. 15A

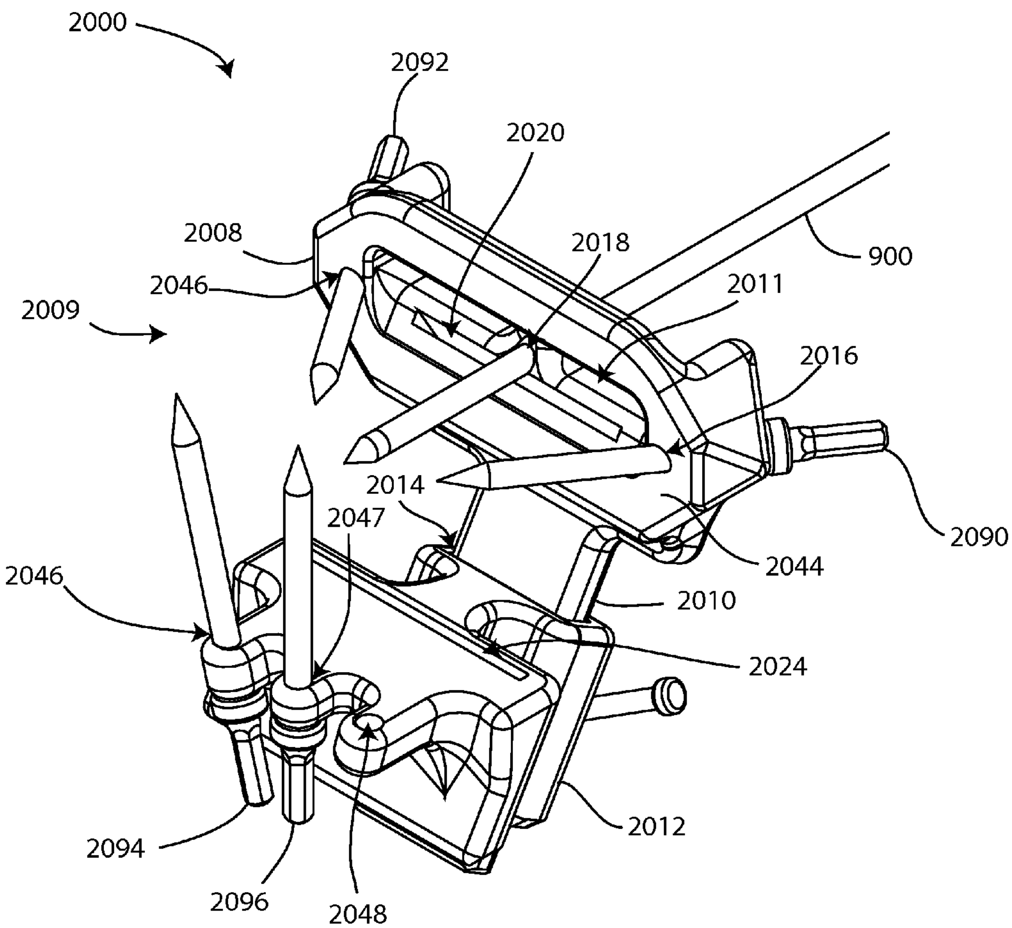
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Fig. 15B

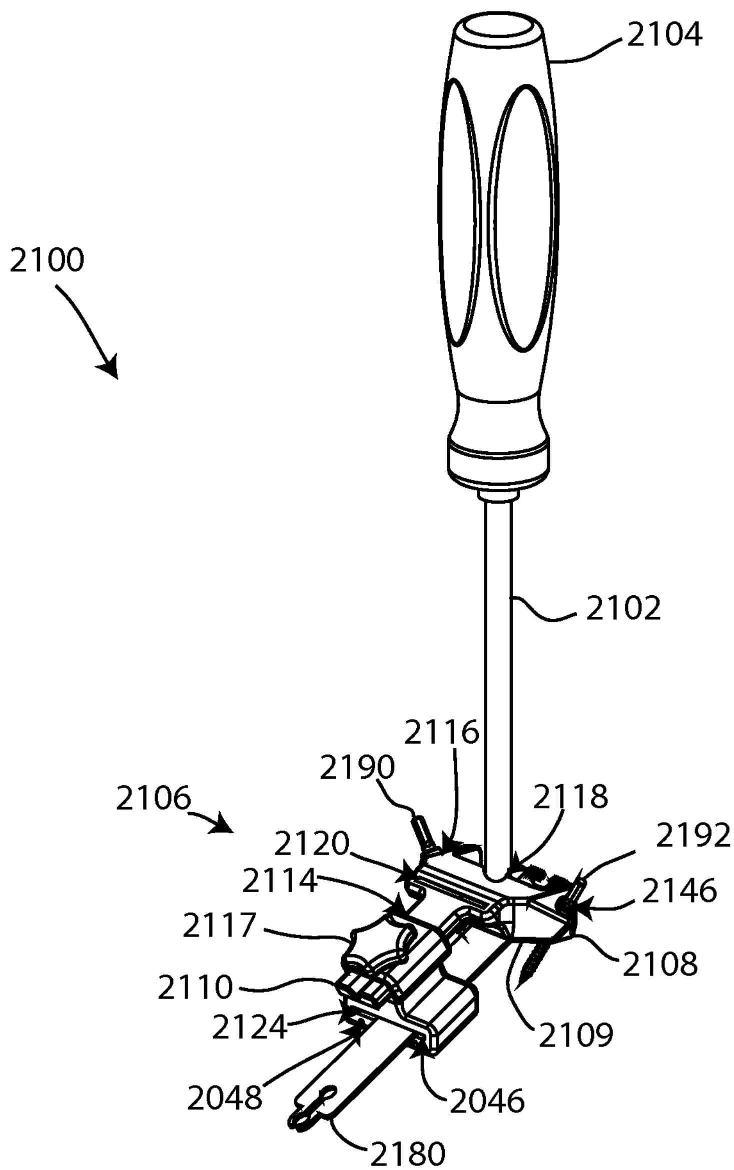
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Fig. 16

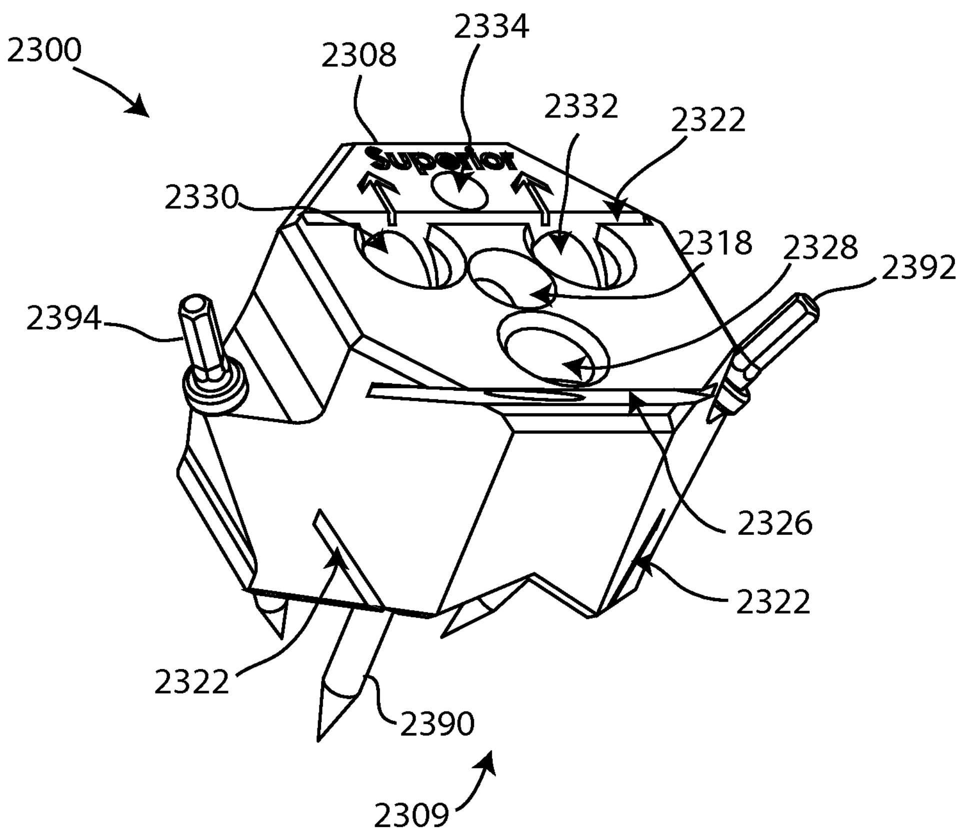
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Fig. 17A

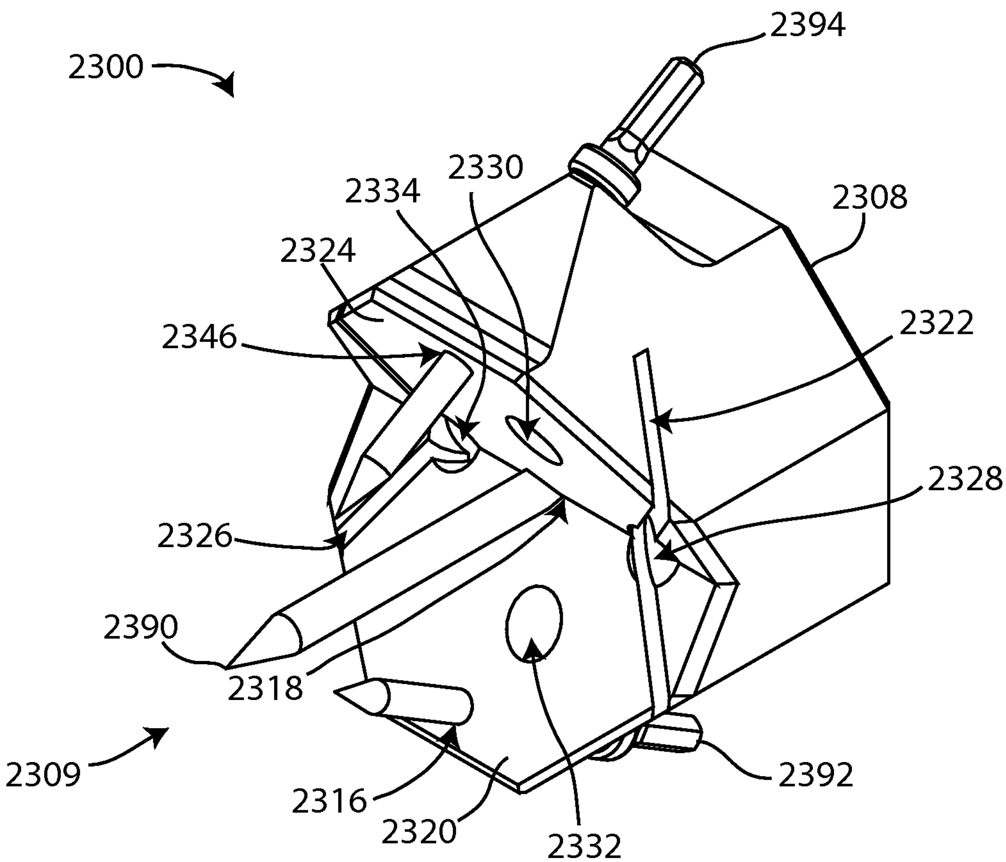
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Fig. 17B

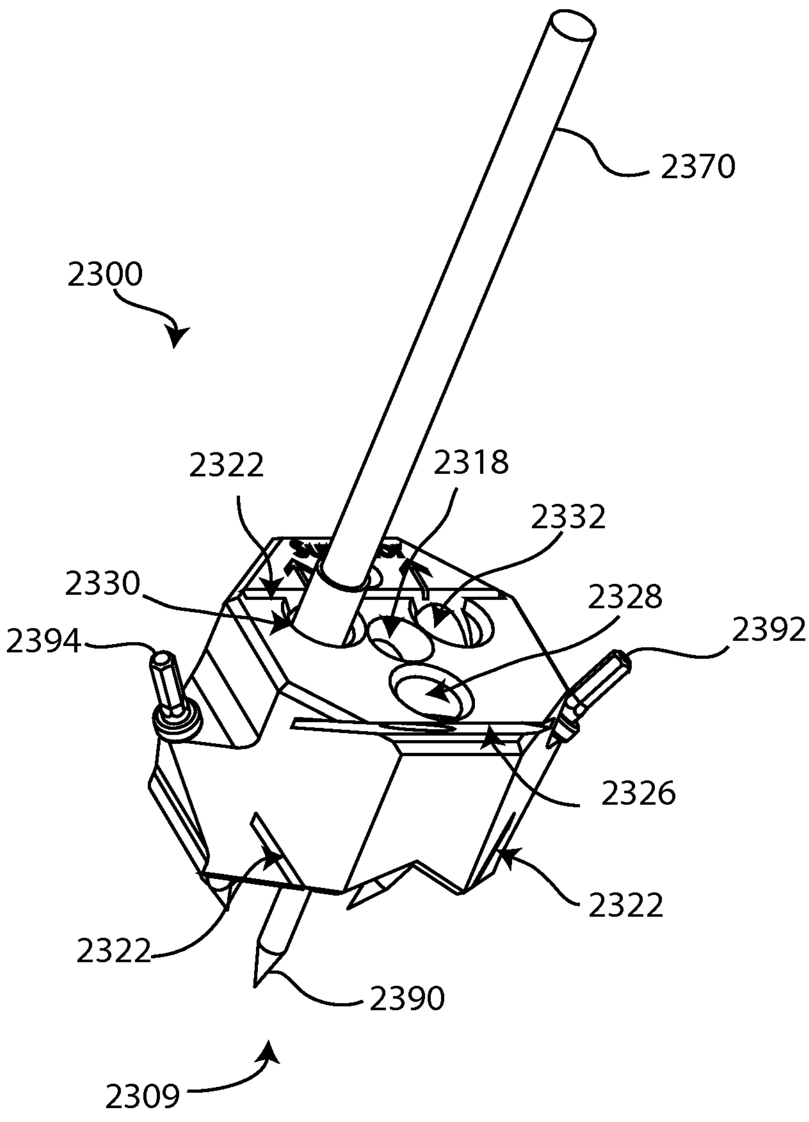
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Fig. 17C

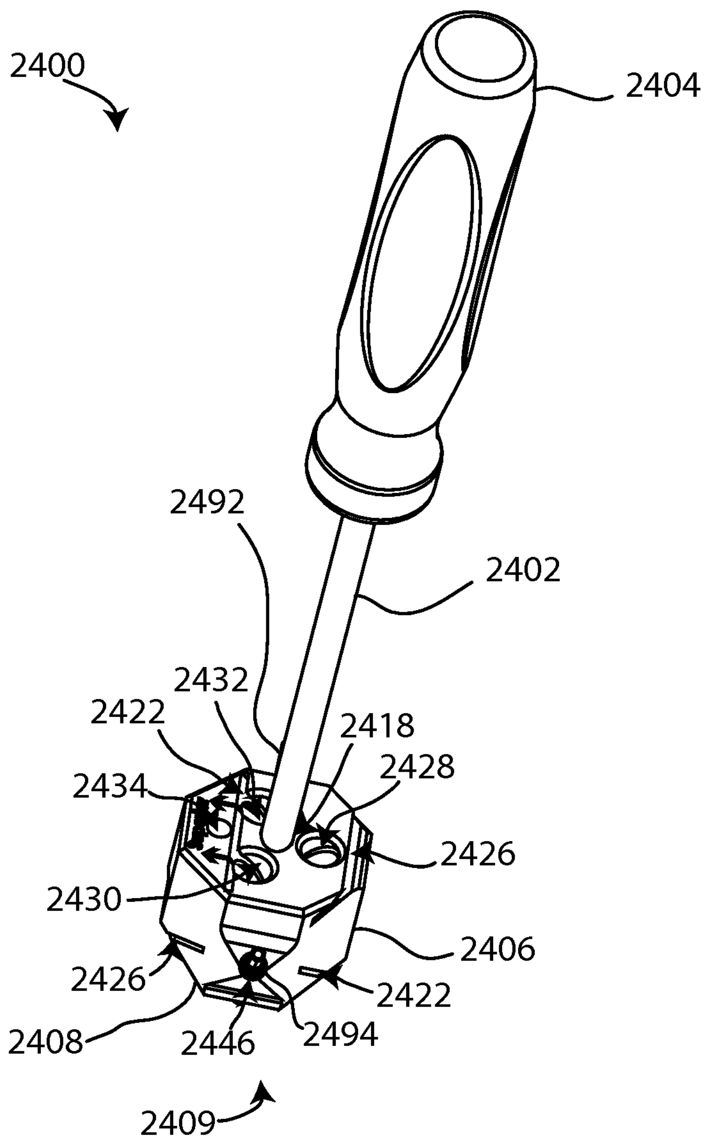
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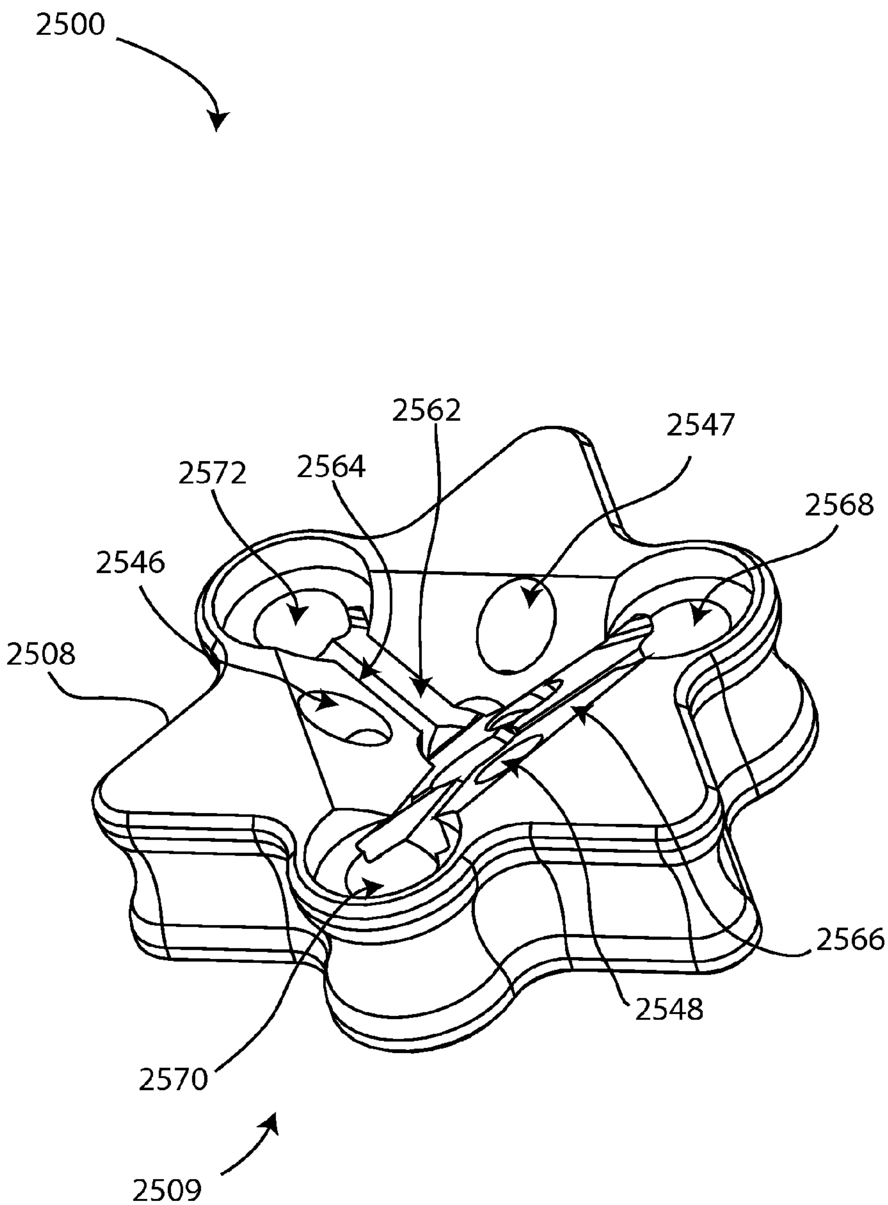
Fig. 18



Fig, 19A

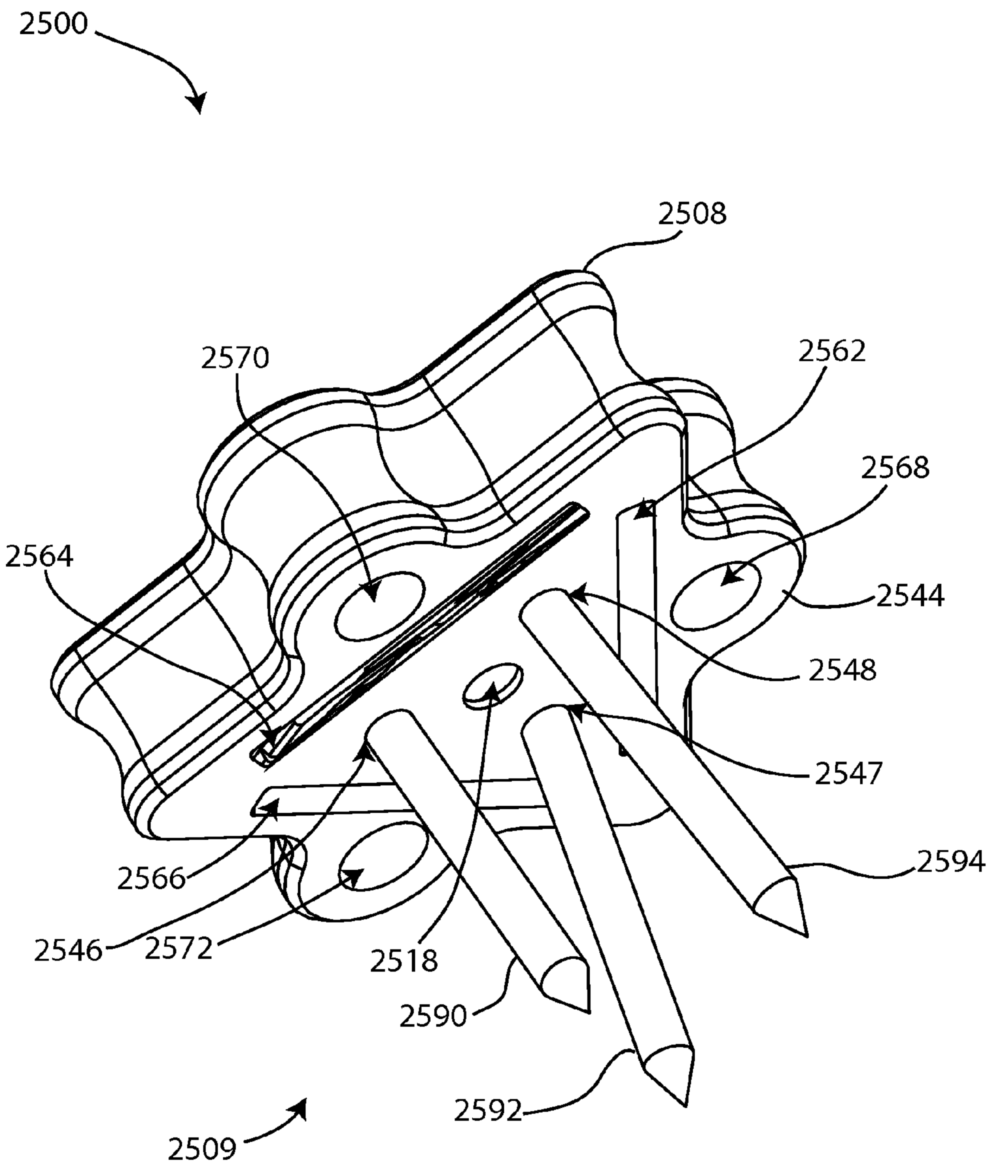

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Fig. 19B

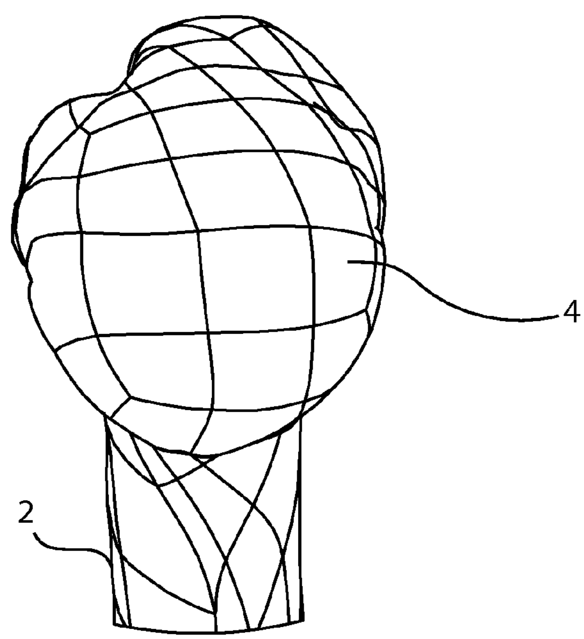

Fig. 20A

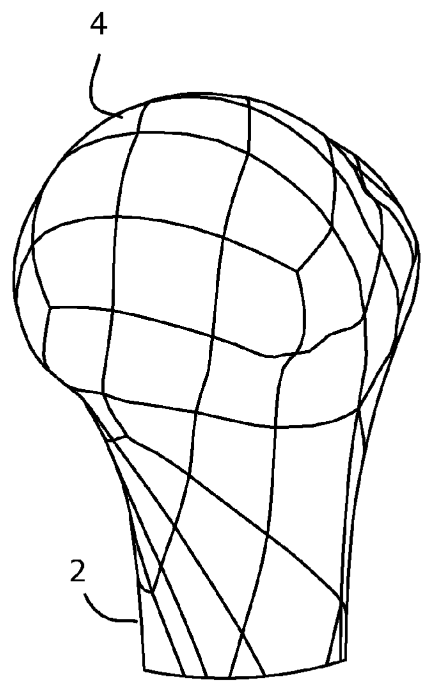

Fig. 20B

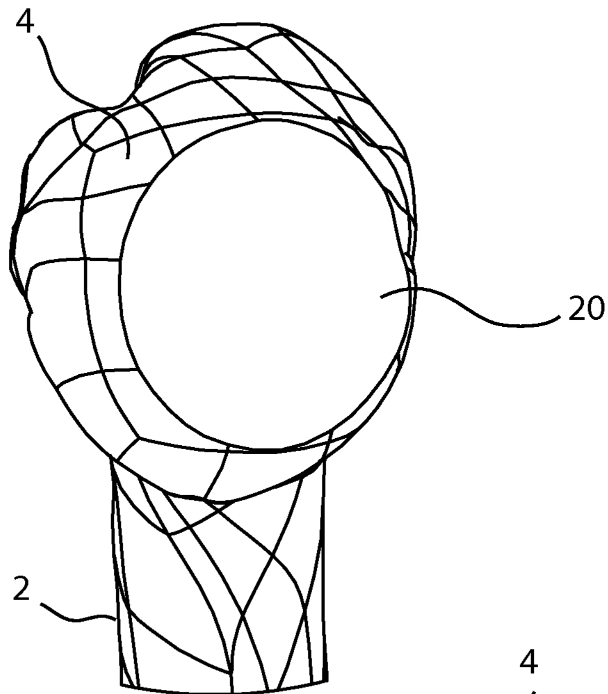

Fig. 21A

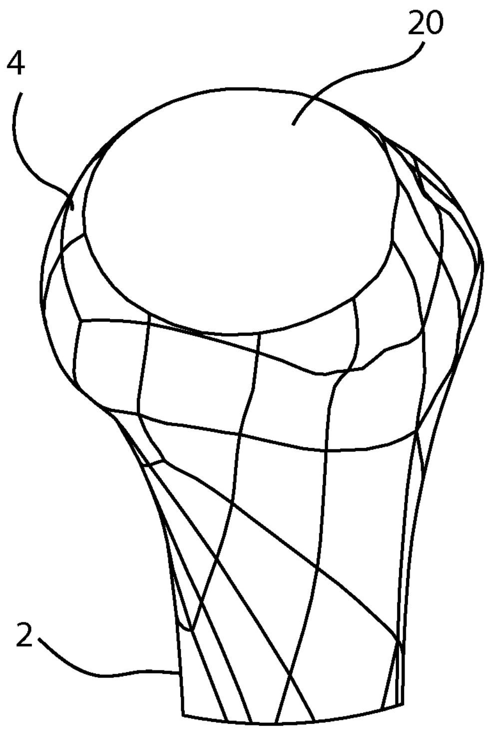

Fig. 21B

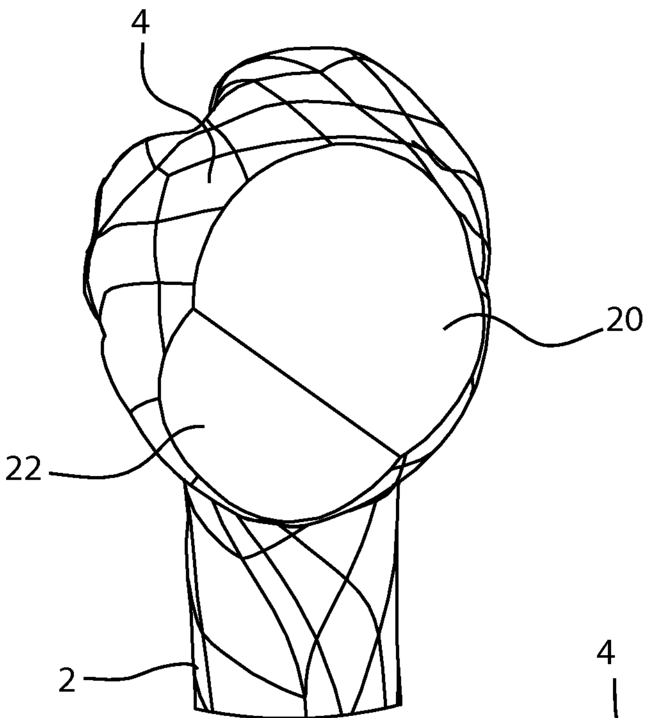

Fig. 22A

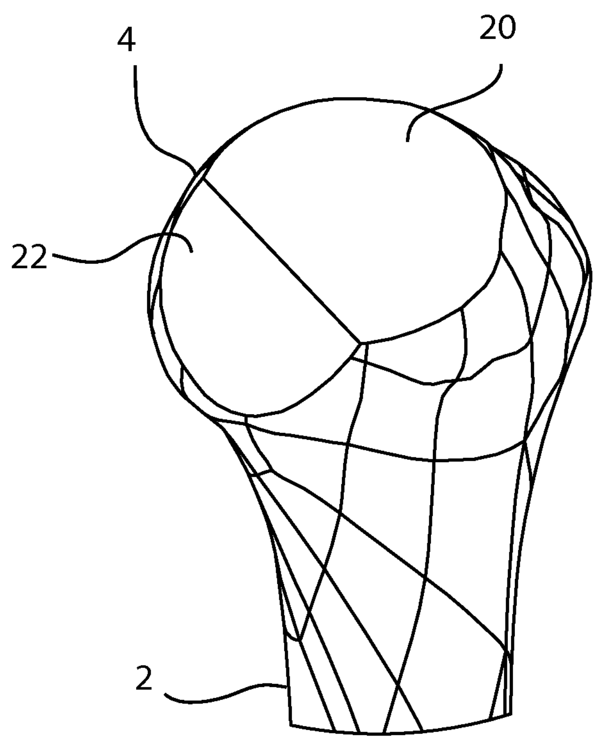

Fig. 22B

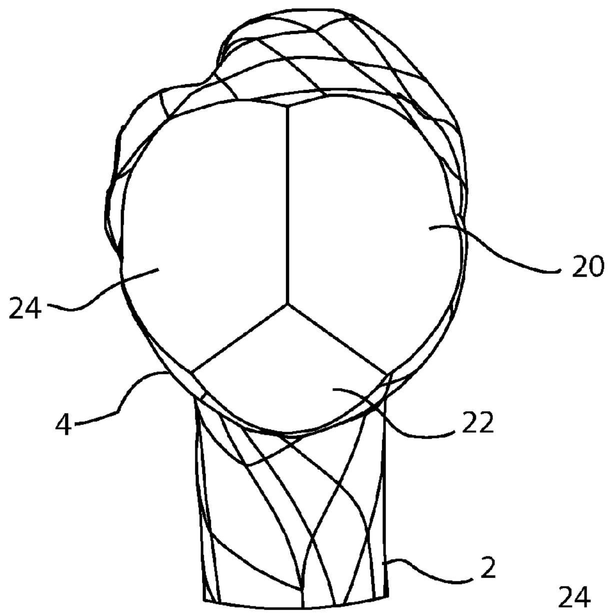

Fig. 23A

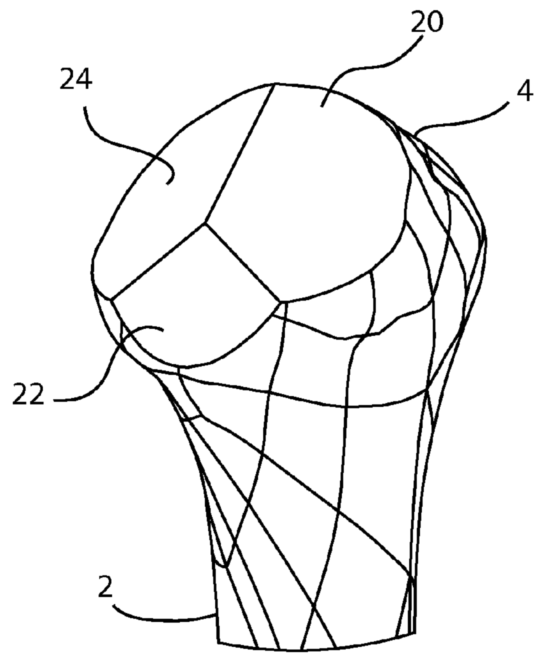

Fig. 23B

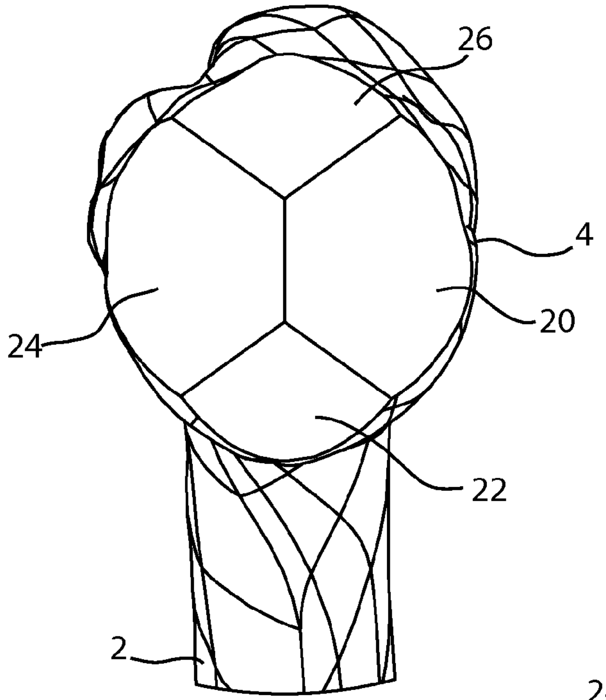

Fig. 24A

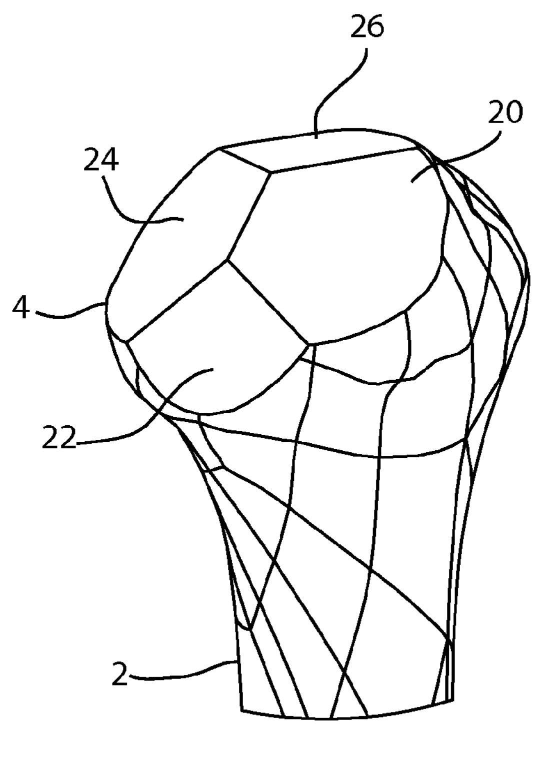

Fig. 24B

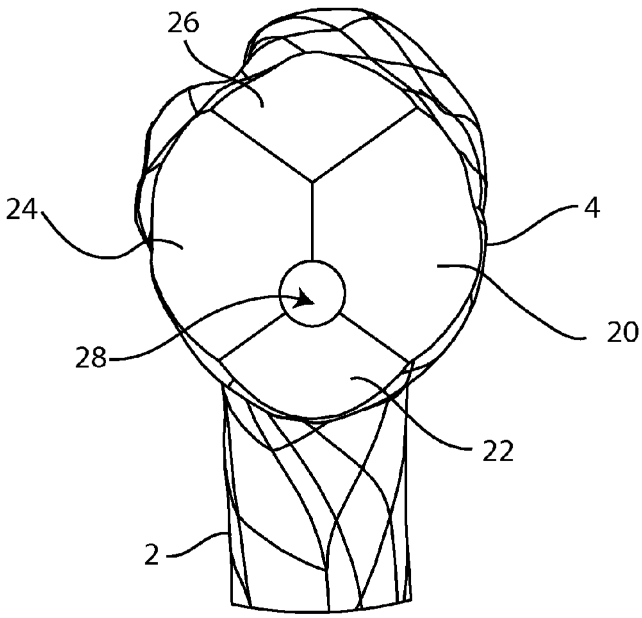

Fig. 25A

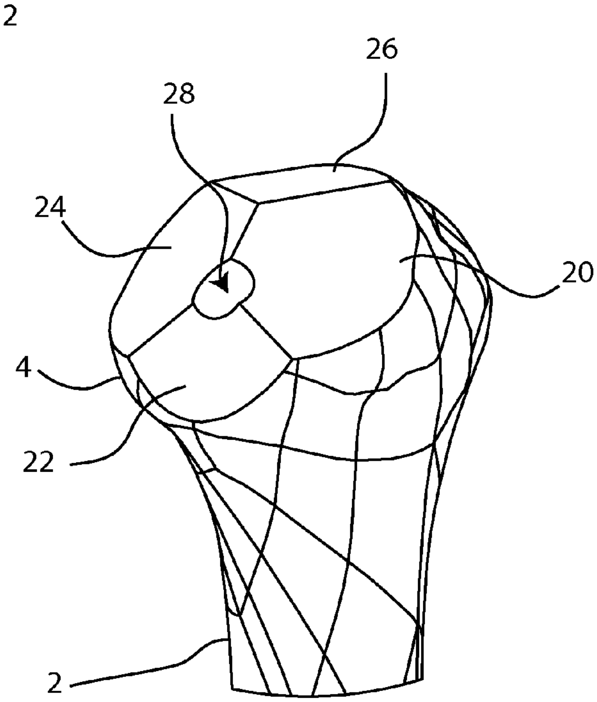

Fig. 25B

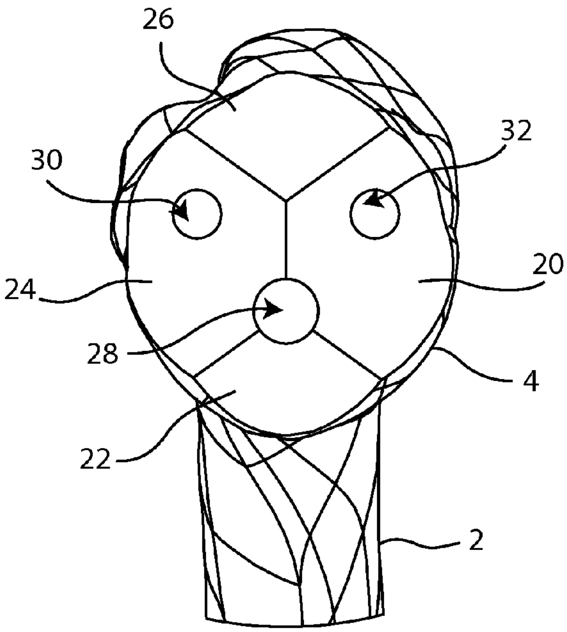

Fig. 26A

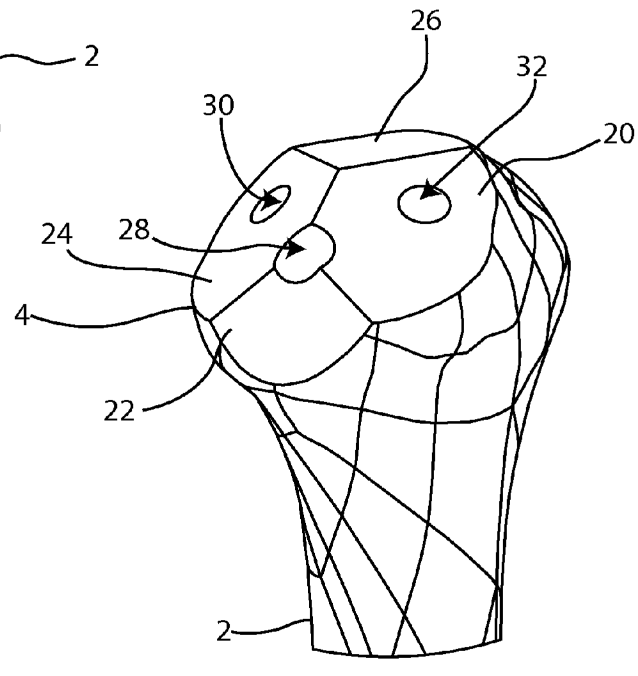

Fig. 26B

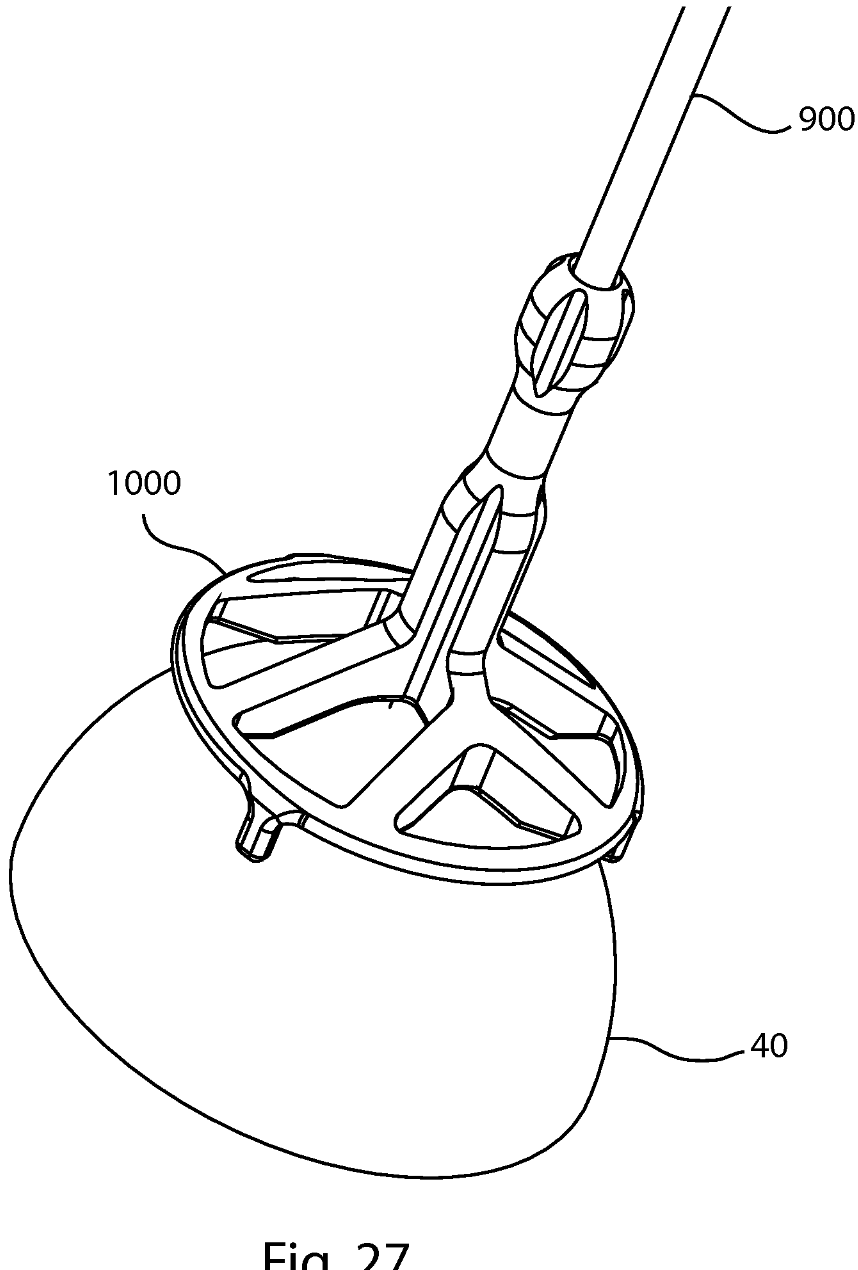

Fig. 27

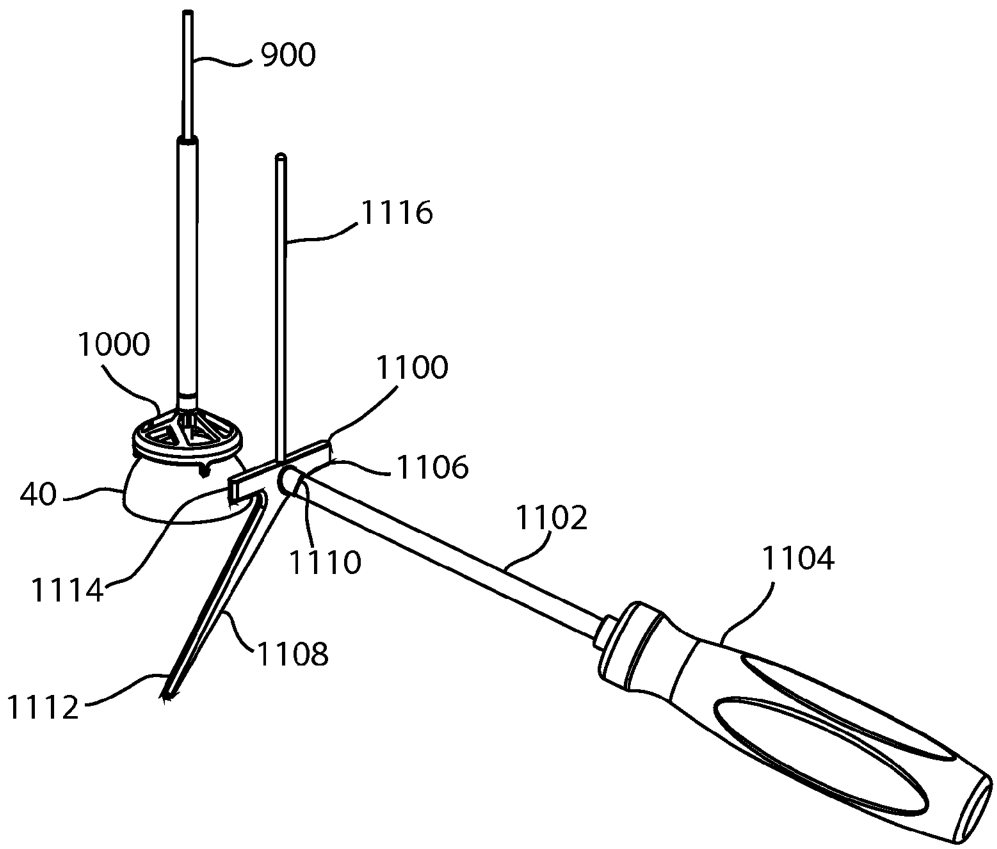

Fig. 28

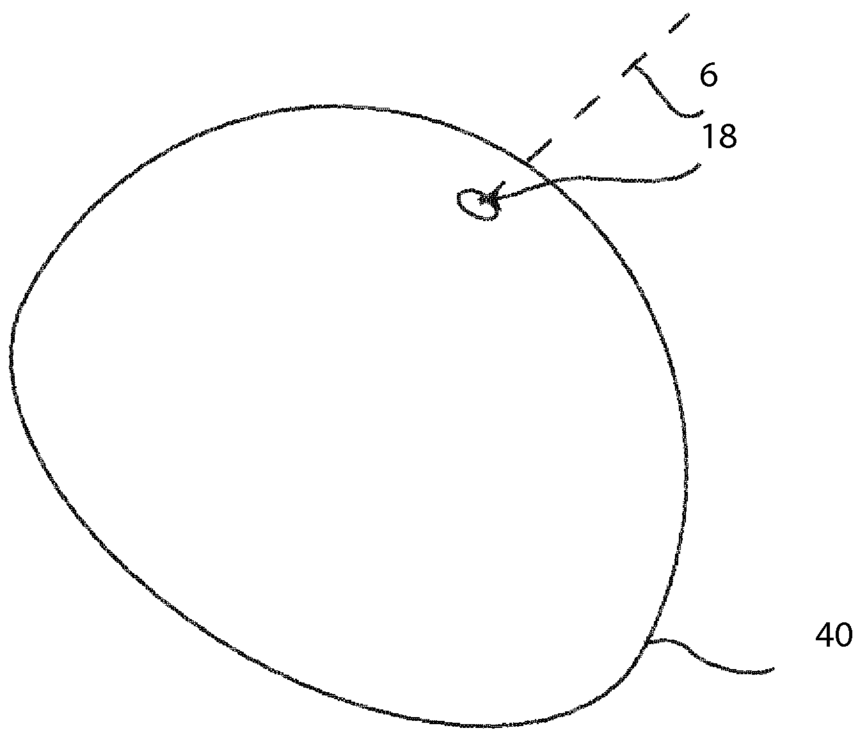

Fig. 29

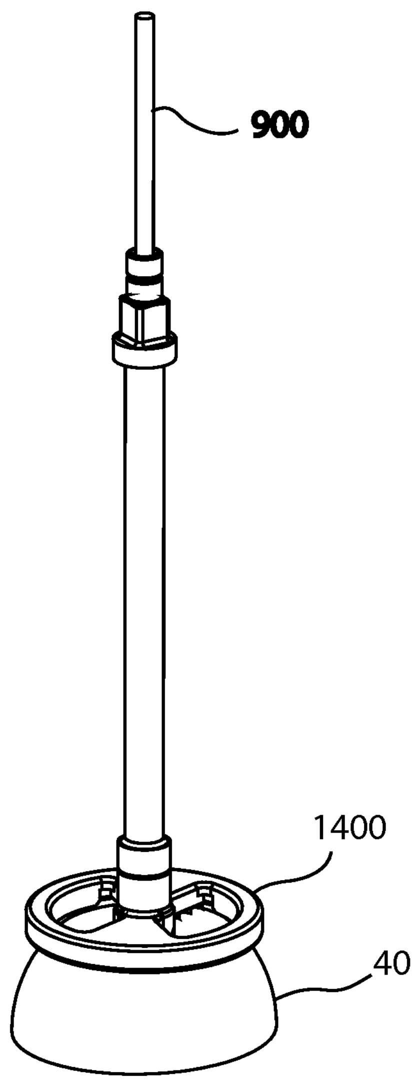

Fig. 30

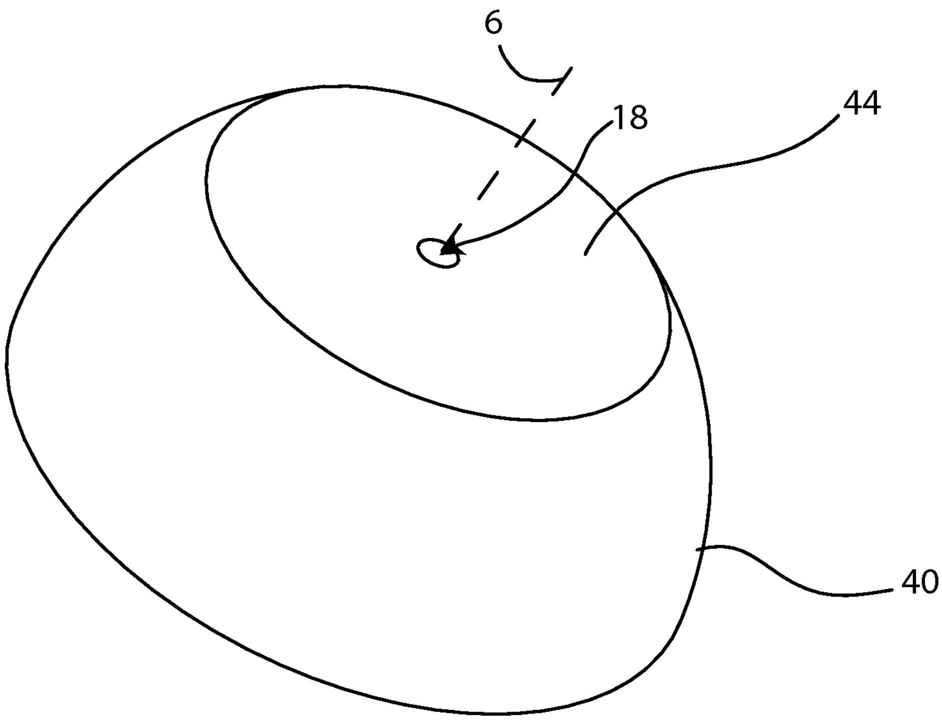

Fig. 31

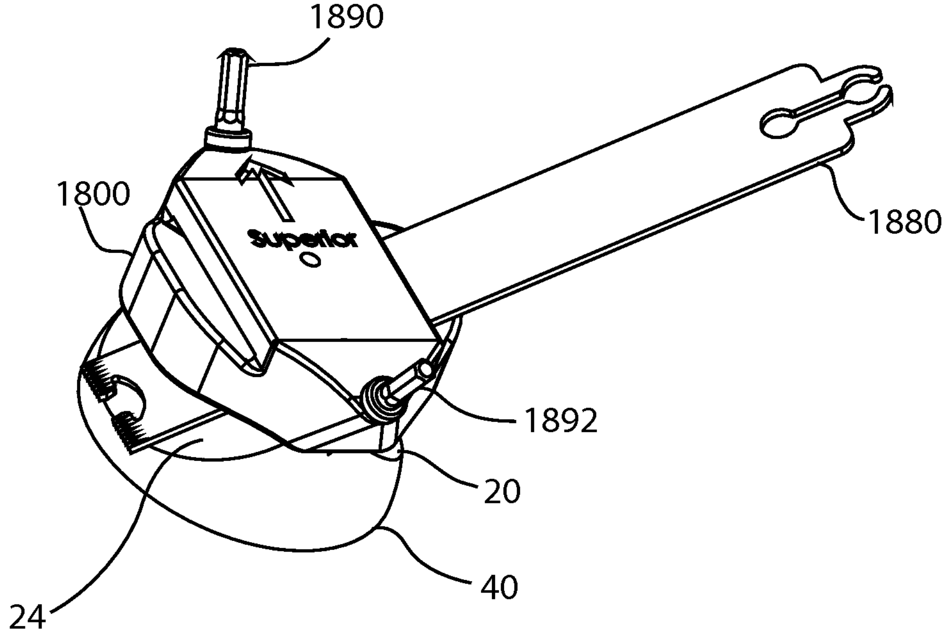

Fig. 32

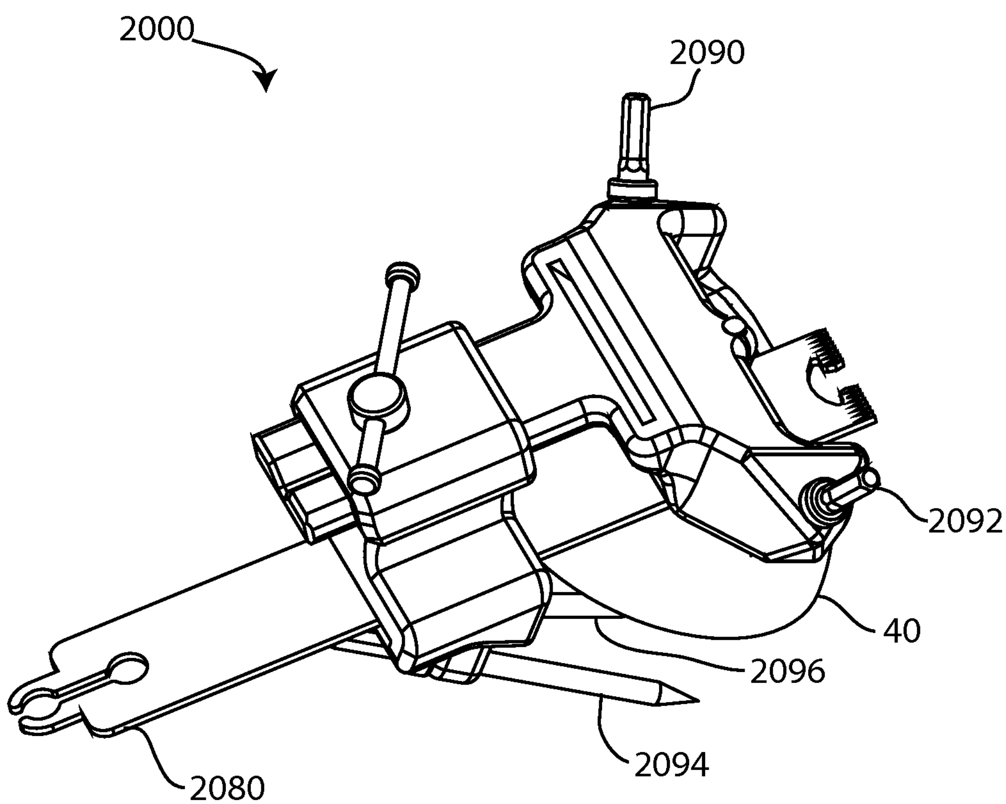

Fig. 33

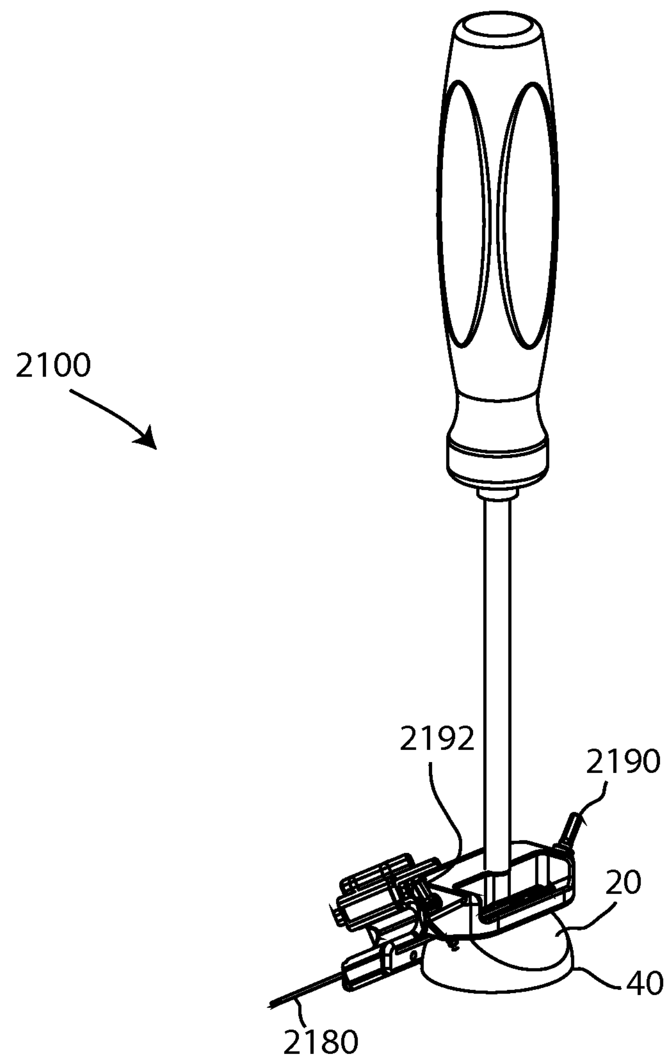

Fig. 34

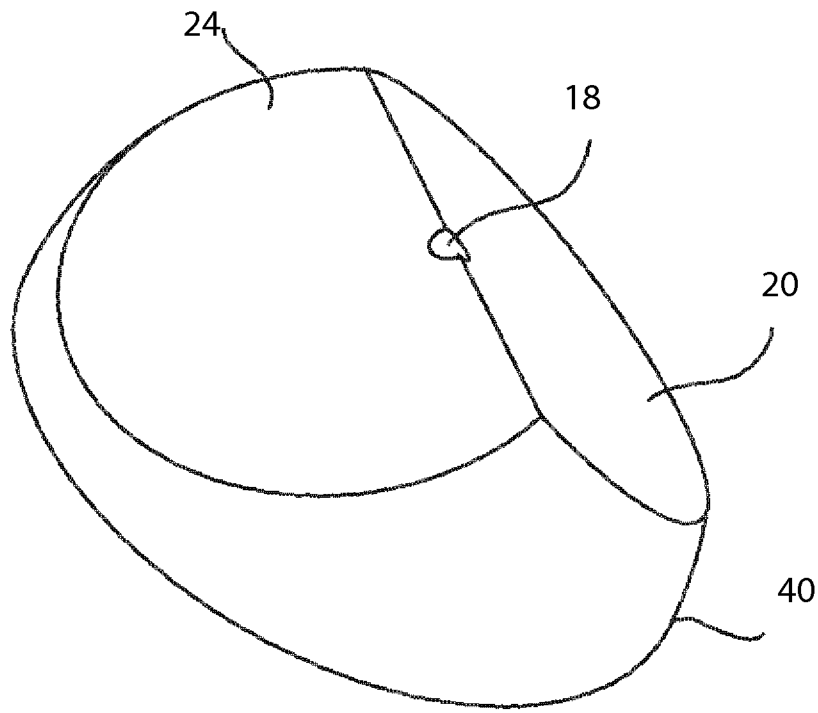

Fig. 35

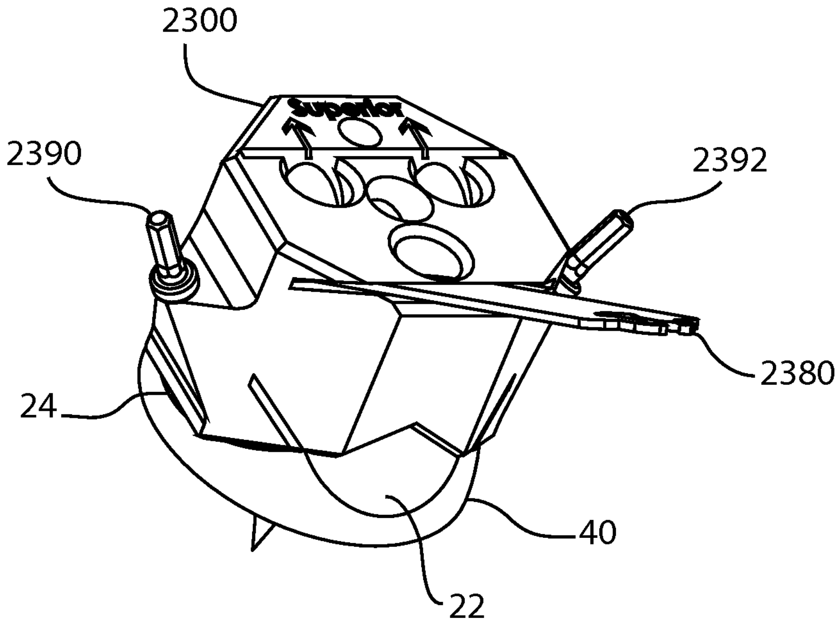

Fig. 36

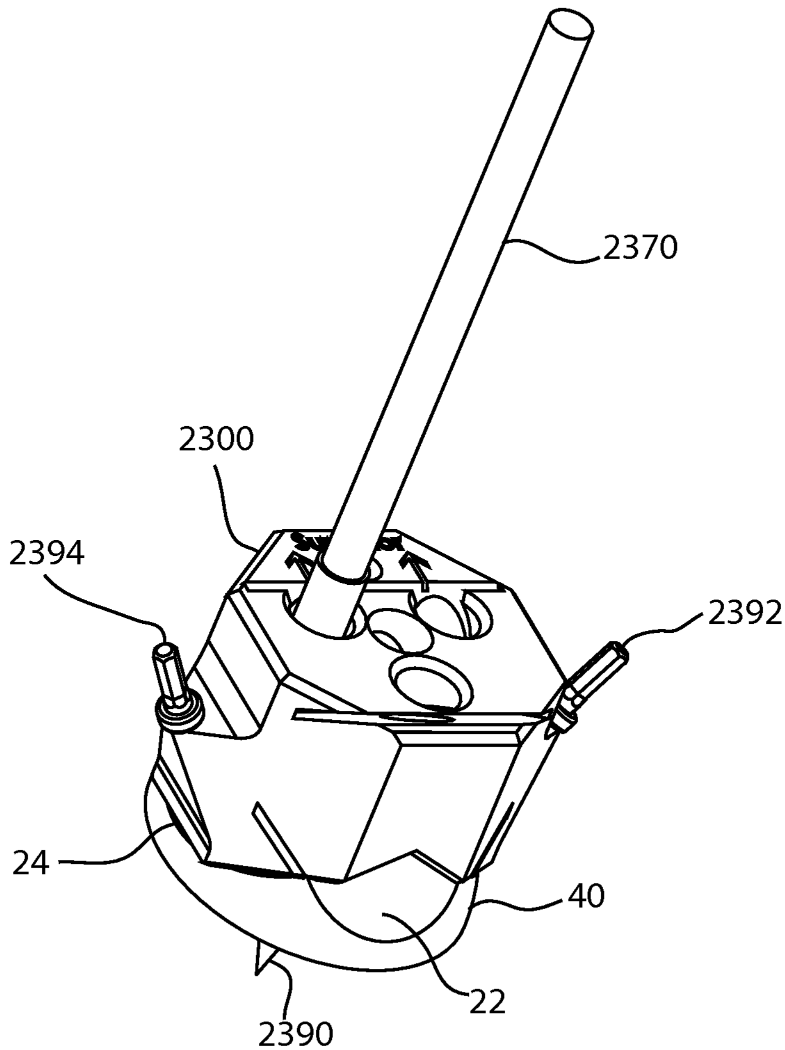

Fig. 37

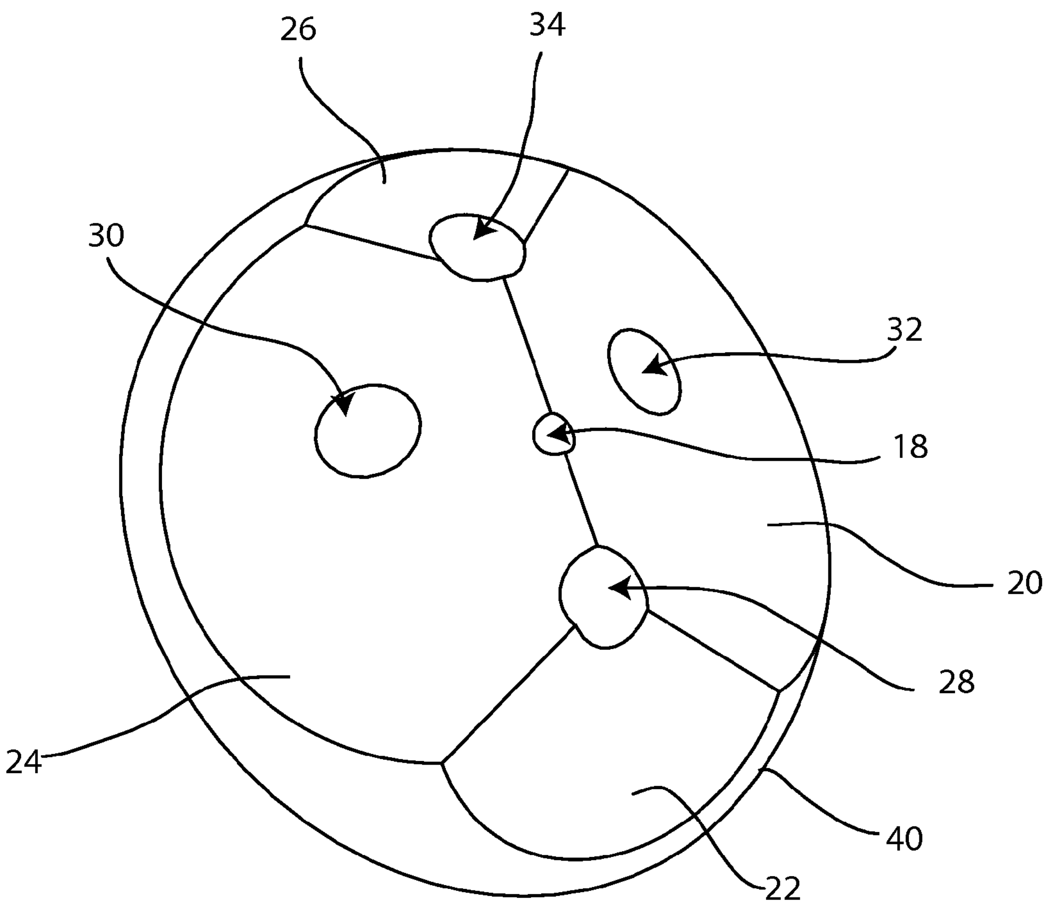

Fig.38

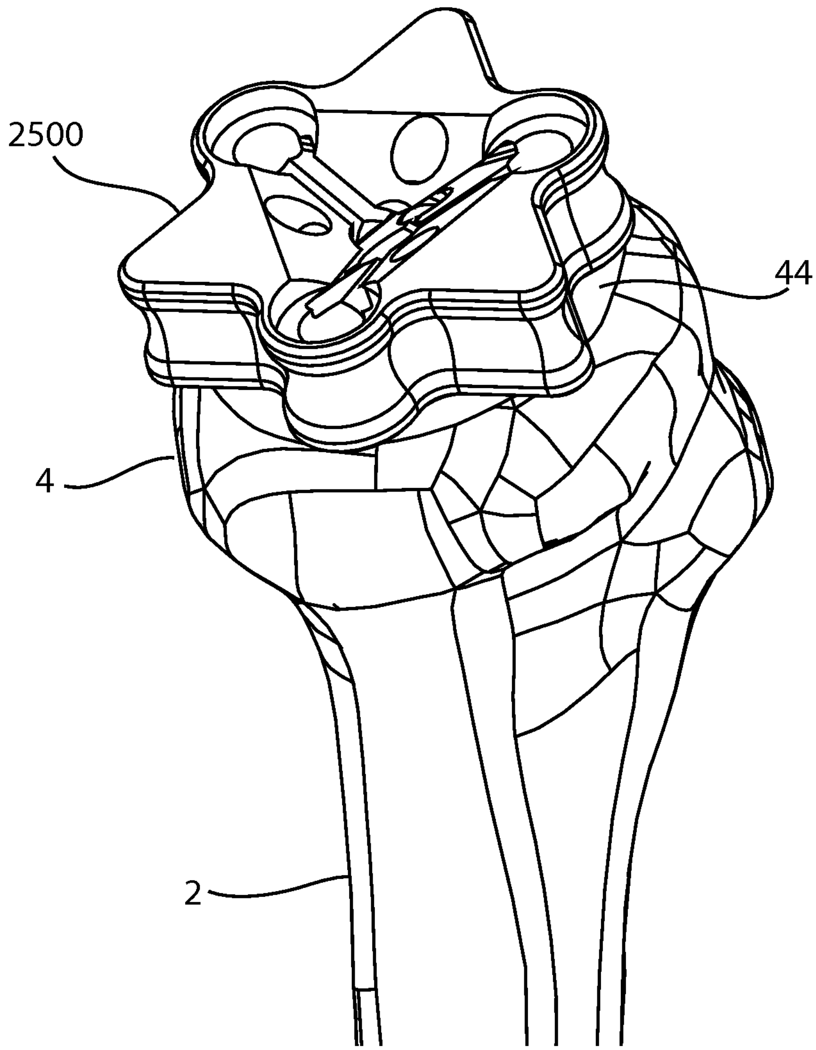

Fig. 39

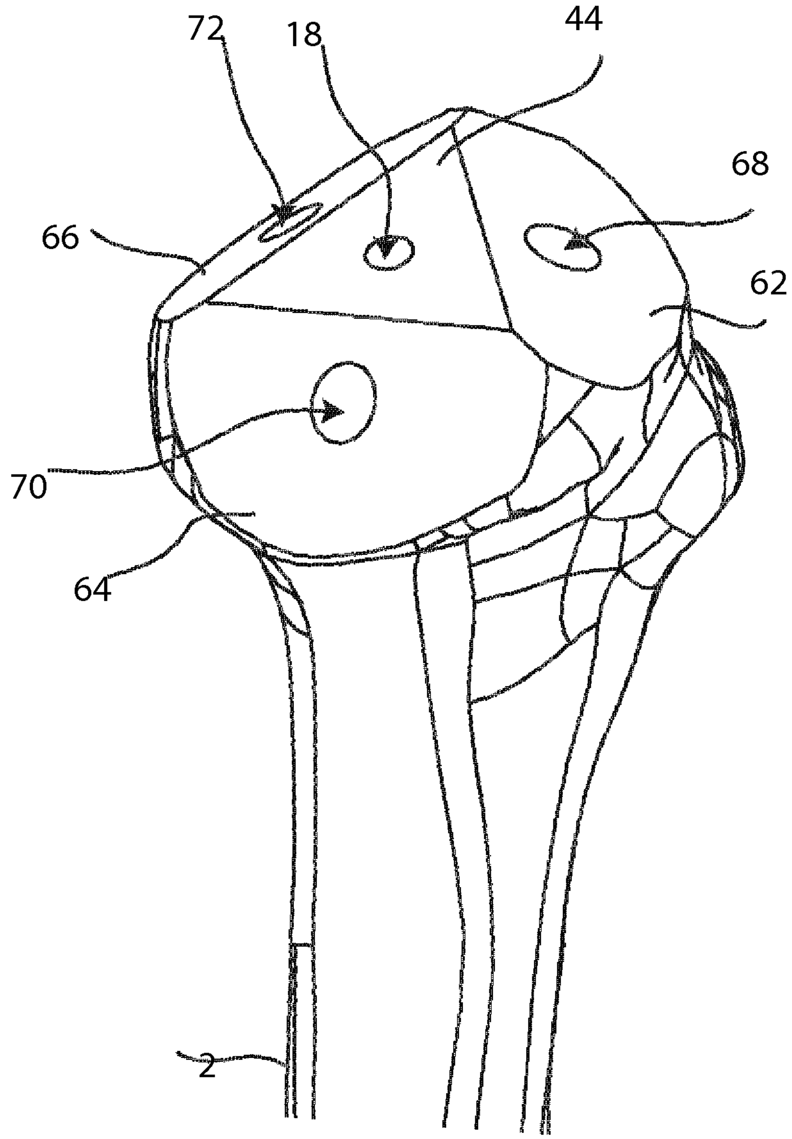

Fig. 40

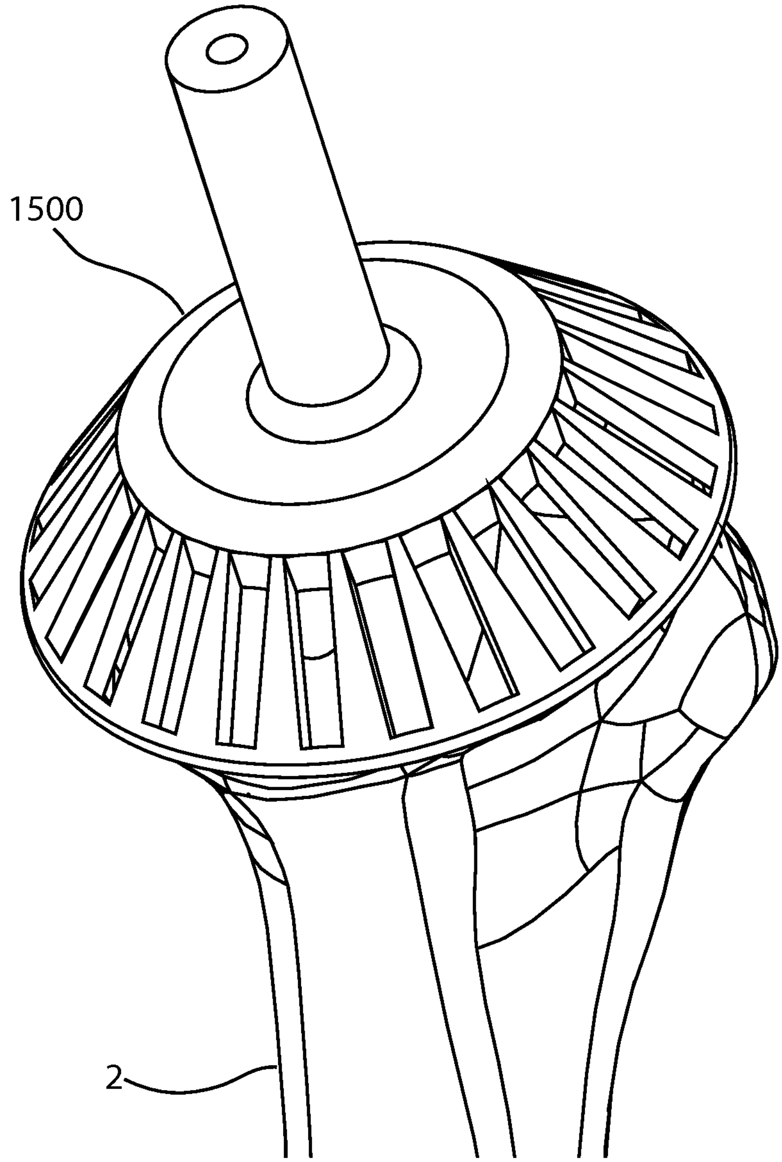

Fig. 41

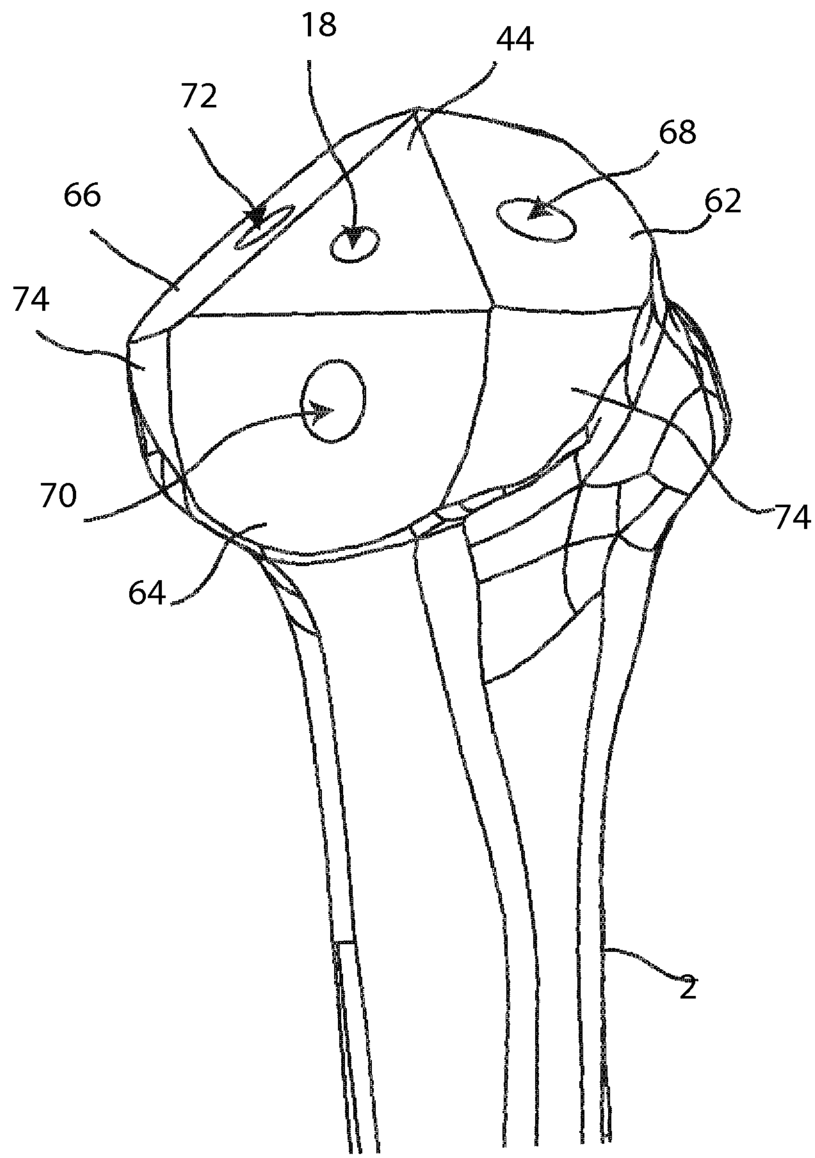

Fig. 42

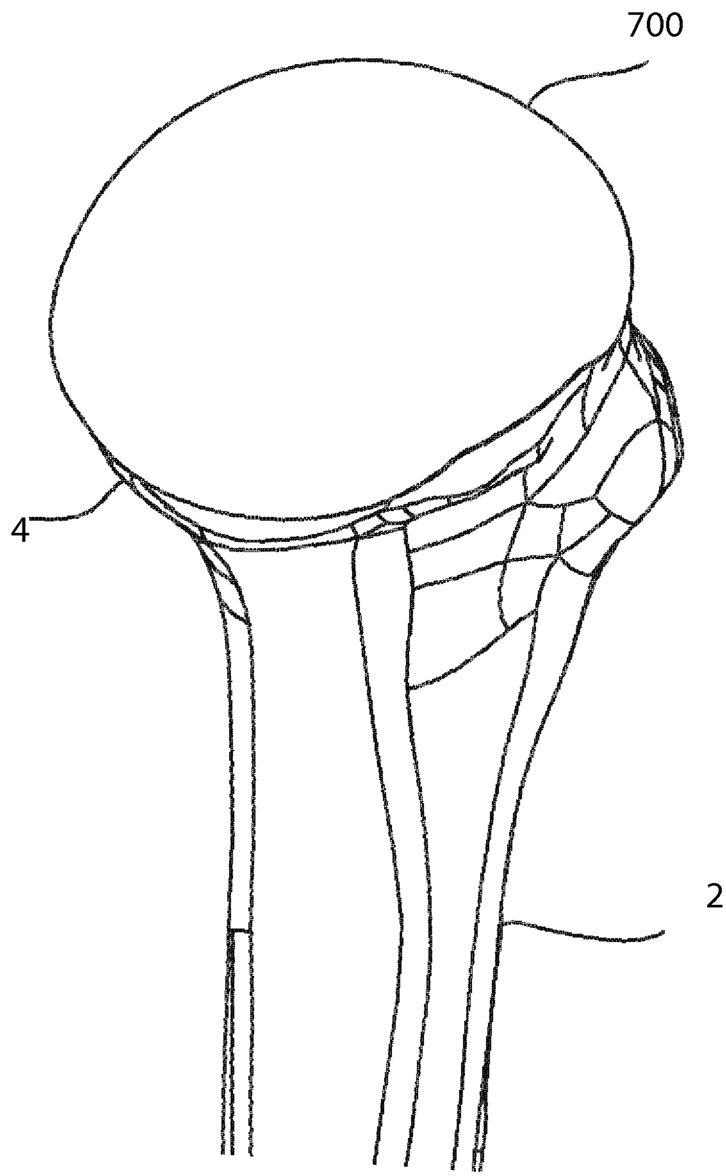

Fig. 43

HUMERAL ARTHROPLASTY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of:

U.S. Provisional Patent Application No. 61/794,348, filed Mar. 15, 2013, entitled HUMERUS PROSTHETIC COMPONENT WITH MULTIPLE CIRCLES OF A SPHERE DESIGN AND ASSOCIATED INSTRUMENTATION.

The above referenced document is incorporated herein by reference in its entirety.

BACKGROUND

In total shoulder arthroplasty, a glenoid implant is attached to a prepared glenoid or scapula, and a humeral implant is attached to a prepared humerus. The humeral implant usually includes a convex articular surface, at a proximal end thereof which engages and moves relative to a concave articular surface formed in the glenoid implant, although this arrangement is sometimes reversed so that the humeral implant includes the convex articular surface and the glenoid implant includes the convex articular surface. The ligaments and muscles of the shoulder surround the implants and maintain the humeral implant against the glenoid implant, while at the same time allowing relative movement therebetween.

Current anatomic prostheses for the proximal humerus generally fall into two types: stemmed prostheses and resurfacing prostheses.

Stemmed prostheses are quite common. Stemmed prostheses combine a hemispherical head replacement with a stem which extends into the shaft (diaphysis) of the humerus to anchor the prosthesis. Stemmed prostheses often require the removal of the entire hemisphere of humeral head bone, as well as drilling, reaming and/or broaching into the adjacent shaft of the humerus to seat the component. The hemispherical head component and stem are typically solid metal and can be of considerable weight. Stemmed prostheses also frequently require the surgeon to place the humeral head articular bearing surface in a position which is either fixed relative to the shaft of the humerus, or has modular adjustable connection mechanisms allowing partial adjustment between the placement of the hemispherical head component and the stem placed in the shaft of the humerus. This may not always match the actual anatomy of the patient, especially if deformity is present. Although many current prostheses provide for adjustments such as retroversion, offset, or neck-shaft angle, these adjustments are always limited to some degree, or constrained, by the stem to which the prosthetic humeral head is attached.

Resurfacing prostheses have a hollow hemisphere which rests on top of the humeral bone with a solitary peg or post in the humeral head for anchoring stability. Resurfacing prostheses have the advantage of resting directly on top of the bone of the upper humerus and do not have a stem that extends into the shaft of the humerus. Therefore the surgeon is free to place the prosthesis based on each individual patient's anatomy. Resurfacing prostheses also do not require the removal of the entire humeral head bone; simply the upper articular end is reshaped to accept the prosthesis sitting on top. The prosthesis itself acts as a surface cover, and the volume of bone underneath in the hemisphere remains. This preserves more of the patient's bone stock and if revision surgery is needed, allows for a much simpler re-operation because the shaft has not yet been violated.

The preservation of bone in the upper humerus with a resurfacing prosthesis may unfortunately become a disadvantage when the surgeon performs a total shoulder arthroplasty. In this operation, the surgeon also places a prosthesis into the glenoid cavity of the scapula. With the bone of the upper humerus still in the way, access to the glenoid may be very difficult and placing the glenoid prosthesis properly can be challenging.

BRIEF DESCRIPTION OF THE DRAWINGS

While examples of the present technology have been shown and described in detail below, it will be clear to the person skilled in the art that variations, changes and modifications may be made without departing from its scope. As such, that which is set forth in the following description and accompanying drawings is offered by way of illustration only and not as a limitation. The actual scope of the invention is intended to be defined by the following claims, along with the full range of equivalents to which such claims are entitled.

Identical reference numerals do not necessarily indicate an identical structure. Rather, the same reference numeral may be used to indicate a similar feature or a feature with similar functionality. Not every feature of each example is labeled in every figure in which that example appears, in order to keep the figures clear. Similar reference numbers (e.g., those that are identical except for the first numeral) are used to indicate similar features in different examples.

FIG. **1**A is an isometric view of a humeral component; FIG. **1**B is a medial view of the humeral component of FIG. **1**A; FIG. **1**C is a cross sectional view of the humeral component of FIG. **1**A, taken along section line **1**C-**1**C of FIG. **1**E; FIG. **1**D is a superior view of the humeral component of FIG. **1**A; FIG. **1**E is a lateral view of the humeral component of FIG. **1**A; and FIG. **1**F is a cross sectional view of the humeral component of FIG. **1**A, taken along section line **1**F-**1**F of FIG. **1**E;

FIG. **2**A is an isometric view of another humeral component; FIG. **2**B is a medial view of the humeral component of FIG. **2**A; FIG. **2**C is a cross sectional view of the humeral component of FIG. **2**A, taken along section line **2**C-**2**C of FIG. **2**E; FIG. **2**D is a superior view of the humeral component of FIG. **2**A; FIG. **2**E is a lateral view of the humeral component of FIG. **2**A; and FIG. **2**F is a cross sectional view of the humeral component of FIG. **2**A, taken along section line **2**F-**2**F of FIG. **2**E;

FIG. **3**A is an isometric view of yet another humeral component; FIG. **3**B is a medial view of the humeral component of FIG. **3**A; FIG. **3**C is a cross sectional view of the humeral component of FIG. **3**A, taken along section line **3**C-**3**C of FIG. **3**E; FIG. **3**D is a superior view of the humeral component of FIG. **3**A; FIG. **3**E is a lateral view of the humeral component of FIG. **3**A; and FIG. **3**F is a cross sectional view of the humeral component of FIG. **3**A, taken along section line **3**F-**3**F of FIG. **3**E;

FIG. **4**A is an isometric view of yet another humeral component; and FIG. **4**B is a lateral view of the humeral component of FIG. **4**A;

FIG. **5**A is an isometric view of yet another humeral component; and FIG. **5**B is a lateral view of the humeral component of FIG. **5**A;

FIG. **6**A is a superior view of yet another humeral component; FIG. **6**B is an anterior view of the humeral component of FIG. **6**A; FIG. **6**C is a medial view of the humeral component of FIG. **6**A; FIG. **6**D is an isometric view of the humeral component of FIG. **6**A; FIG. **6**E is an inferior view of the humeral component of FIG. **6**A; FIG. **6**F is a cross sectional view of the humeral component of FIG. **6**A, taken along section line 6F-6F of FIG. 6C, with superimposed cross sectional profiles of two other size humeral components; FIG. 6G is a cross sectional view of the humeral component of FIG. 6A, taken along section line 6G-6G of FIG. 6C, with superimposed cross sectional profiles of two other size humeral components; FIG. 6H is a front left perspective view of the humeral component of FIG. 6A; FIG. 6I is a back left perspective view of the humeral component of FIG. 6A; FIG. 6J is a back view of the humeral component of FIG. 6A; FIG. 6K is a front view of the humeral component of FIG. 6A; FIG. 6L is a right side view of the humeral component of FIG. 6A; FIG. 6M is a left side view of the humeral component of FIG. 6A; FIG. 6N is a top view of the humeral component of FIG. 6A; FIG. 6O is a bottom view of the humeral component of FIG. 6A; FIG. 6P is a cross sectional view of a left portion of the humeral component of FIG. 6A taken along line 6P-6P of FIG. 6J; and FIG. 6Q is a cross sectional view of a bottom portion of the humeral component of FIG. 6A taken along line 6Q-6Q of FIG. 6J;

FIG. 7A is an isometric view of yet another humeral component; FIG. 7B is a superior view of the humeral component of FIG. 7A; FIG. 7C is an anterior view of the humeral component of FIG. 7A; FIG. 7D is a lateral view of the humeral component of FIG. 7A; FIG. 7E is a cross sectional view of the humeral component of FIG. 7A, taken along section line 7E-7E of FIG. 7D; and FIG. 7F is a cross sectional view of the humeral component of FIG. 7A, taken along section line 7F-7F of FIG. 7D;

FIG. 8A is an isometric view of yet another humeral component; FIG. 8B is a lateral view of the humeral component of FIG. 8A; FIG. 8C is a cross sectional view of the humeral component of FIG. 8A, taken along section line 8C-8C of FIG. 8B; and FIG. 8D is a cross sectional view of the humeral component of FIG. 8A, taken along section line 8D-8D of FIG. 8B;

FIG. 9A is an isometric view of a pin and a template; and FIG. 9B is another isometric view of the template of FIG. 9A from a different viewpoint;

FIG. 10A is an isometric view of the pin of FIG. 9A and a planar reamer; and FIG. 10B is another isometric view of a portion of the pin and planar reamer of FIG. 10A from a different viewpoint;

FIG. 11A is an isometric view of a conical reamer; and FIG. 11B is another isometric view of the conical reamer of FIG. 11A from a different viewpoint;

FIG. 12A is a top view of a cutting guide; FIG. 12B is a cross sectional view of the cutting guide of FIG. 12A, taken along section line 12B-12B of FIG. 12A; FIG. 12C is a front view of the cutting guide of FIG. 12A; FIG. 12D is a side view of the cutting guide of FIG. 12A; FIG. 12E is a bottom view of the cutting guide of FIG. 12A; and FIGS. 12F, 12G, 12H, 12I, and FIG. 12J are isometric views of the cutting guide of FIG. 12A from several different viewpoints;

FIG. 13A is an isometric view of another cutting guide with the pin of FIG. 9A and two fasteners; and FIG. 13B is another isometric view of the cutting guide, pin, and fasteners of FIG. 13A from a different viewpoint;

FIG. 14 is an isometric view of yet another cutting guide with two fasteners;

FIG. 15A is an isometric view of yet another cutting guide with the pin of FIG. 9A and four fasteners; and FIG. 15B is another isometric view of the cutting guide, pin, and fasteners of FIG. 15A from a different viewpoint;

FIG. 16 is an isometric view of yet another cutting guide with two fasteners and a saw blade;

FIG. 17A is an isometric view of yet another cutting guide with three fasteners; FIG. 17B is another isometric view of the cutting guide and fasteners of FIG. 17A from a different viewpoint; and FIG. 17C is another isometric view of the cutting guide and fasteners of FIG. 17A with a drill, from the viewpoint of FIG. 17A;

FIG. 18 is an isometric view of yet another cutting guide with two fasteners;

FIG. 19A is an isometric view of yet another cutting guide; and FIG. 19B is another isometric view of the cutting guide of FIG. 19A with three fasteners, from a different viewpoint;

FIG. 20A is an isometric view of an intact proximal humerus along the humeral neck axis; and FIG. 20B is an isometric view of the proximal humerus of FIG. 20A from a postero-medial viewpoint;

FIG. 21A is an isometric view of the proximal humerus of FIG. 20A along the humeral neck axis after a posterior bone resection has been made; and FIG. 21B is an isometric view of the proximal humerus of FIG. 21A from a postero-medial viewpoint;

FIG. 22A is an isometric view of the proximal humerus of FIG. 21A along the humeral neck axis after an inferior bone resection has been made; and FIG. 22B is an isometric view of the proximal humerus of FIG. 22A from a postero-medial viewpoint;

FIG. 23A is an isometric view of the proximal humerus of FIG. 22A along the humeral neck axis after an anterior bone resection has been made; and FIG. 23B is an isometric view of the proximal humerus of FIG. 23A from a postero-medial viewpoint;

FIG. 24A is an isometric view of the proximal humerus of FIG. 23A along the humeral neck axis after a superior bone resection has been made; and FIG. 24B is an isometric view of the proximal humerus of FIG. 24A from a postero-medial viewpoint;

FIG. 25A is an isometric view of the proximal humerus of FIG. 24A along the humeral neck axis after an inferior bone hole has been made; and FIG. 25B is an isometric view of the proximal humerus of FIG. 25A from a postero-medial viewpoint;

FIG. 26A is an isometric view of the proximal humerus of FIG. 25A along the humeral neck axis after anterior and posterior bone holes have been made; and FIG. 26B is an isometric view of the proximal humerus of FIG. 26A from a postero-medial viewpoint;

FIG. 27 is an isometric view of the template and pin of FIG. 9A operatively arranged relative to a simplified humeral head represented by a hemisphere;

FIG. 28 is an isometric view of the template, pin, and simplified humeral head of FIG. 27 operatively arranged relative to an alignment guide;

FIG. 29 is an isometric view of the simplified humeral head of FIG. 27 after a central pin hole has been made;

FIG. 30 is an isometric view of the planar reamer and pin of FIG. 10A operatively arranged relative to the simplified humeral head of FIG. 29;

FIG. 31 is an isometric view of the simplified humeral head of FIG. 30 after a planar bone resection has been made perpendicular to the pin hole;

FIG. 32 is an isometric view of the cutting guide and fasteners of FIG. 13A and a saw blade operatively arranged relative to the simplified humeral head of FIG. 31;

FIG. 33 is an isometric view of the cutting guide and fasteners of FIG. 15A and a saw blade operatively arranged relative to the simplified humeral head of FIG. 31;

FIG. 34 is an isometric view of the cutting guide and fasteners of FIG. 16 and a saw blade operatively arranged relative to the simplified humeral head of FIG. 31;

FIG. **35** is an isometric view of the simplified humeral head of FIG. **32** after anterior and posterior bone resections have been made;

FIG. **36** is an isometric view of the cutting guide and fasteners of FIG. **17**A and a saw blade operatively arranged relative to the simplified humeral head of FIG. **35**;

FIG. **37** is an isometric view of the cutting guide, fasteners, and simplified humeral head of FIG. **36** operatively arranged relative to the drill of FIG. **17**C;

FIG. **38** is an isometric view of the simplified humeral head of FIG. **37** after superior and inferior bone resections and superior, inferior, anterior, and posterior bone holes have been made;

FIG. **39** is an isometric view of the cutting guide and fasteners of FIG. **19**B operatively arranged with a proximal humerus;

FIG. **40** is an isometric view of the proximal humerus of FIG. **39**, after inferior, antero-superior, and postero-superior bone resections and bone holes have been made;

FIG. **41** is an isometric view of the conical reamer of FIG. **11**A operatively arranged with the proximal humerus of FIG. **40**;

FIG. **42** is an isometric view of the proximal humerus of FIG. **41**, after a conical resection has been made; and

FIG. **43** is an isometric view of the proximal humerus of FIG. **42**, after the humeral component of FIG. **7** has been implanted.

DETAILED DESCRIPTION

Standard medical planes of reference and descriptive terminology are employed in this specification. A sagittal plane divides a body into right and left portions. A mid-sagittal plane divides the body into bilaterally symmetric right and left halves. A coronal plane divides a body into anterior and posterior portions. A transverse plane divides a body into superior and inferior portions. Anterior means toward the front of the body. Posterior means toward the back of the body. Superior means toward the head. Inferior means toward the feet. Medial means toward the midline of the body. Lateral means away from the midline of the body. Axial means toward a central axis of the body. Abaxial means away from a central axis of the body. Ipsilateral means on the same side of the body. Contralateral means on the opposite side of the body. These descriptive terms may be applied to an animate or inanimate body.

One of the objectives of the present technology is to provide a prosthesis for the articular surface of the proximal humerus that allows for a bone preserving and anatomically accurate surgical operation. The disclosed prosthesis requires several small bone cuts to remove a small amount of bone from the upper humerus, but significantly less than a stemmed prosthesis. However the small amount of bone removed may be just enough to allow improved access to a surgeon who also is placing a glenoid prosthesis, especially if the glenoid prosthesis uses an oblique angle of insertion. The disclosed humeral prosthesis still rests on the surface of the upper humerus and does not extend into the humeral shaft, unless the surgeon chooses to use a longer stemmed example.

The disclosed humeral prosthesis can be modified by varying the size, angle and relative location of each individual circle of a sphere relative to the other circles. The prosthesis may be altered in discrete regions to adapt the component precisely to cover or avoid certain surrounding anatomical structures, such as the rotator cuff tendon insertions of the teres minor, infraspinatus, supraspinatus, and subscapularis muscles. This cannot be done with a prosthesis designed as a single hemisphere and having an articular margin which lies on a plane.

Another design, known as a stemless hemiarthroplasty prosthesis, also uses a hemispherical humeral head implant placed on top of the upper humerus after a standard humeral head cut has been made. Though this design does not require the placement of a stem, the solid large metal head is of the same volume and weight as a comparable head used in a stemmed design, but is anchored by a shallow fixation apparatus.

An objective of the present technology is to disclose a prosthesis for the articular surface of the proximal humerus having overlapping circles of a sphere.

Another objective of the present technology is to disclose a prosthesis for the articular surface of the proximal humerus having an ellipsoid shape of the humeral articular surface.

Still another objective of the present technology is to disclose a prosthesis for the articular surface of the proximal humerus having a long stem example of a resurfacing type prosthesis.

Another objective of the present technology is to disclose a cutting guide instrument used to prepare the bone to seat the humerus prosthesis.

Advantages of the present technology include the multiple joined circle-of-a-sphere design, which requires less removal of bone than a standard hemiarthroplasty. Due to significantly reduced volume, the metal humeral component weighs significantly less than a standard hemispherical humeral component of corresponding size, but provides nearly equal surface area coverage of the proximal humeral articular surface. The reduced weight of the humeral component may improve shoulder kinematics. The reduced weight of the humeral component may also contribute to improved long-term stability by reducing loosening forces placed on the anchoring elements. Reduced volume of metal may also potentially reduce material costs of manufacturing the implant.

The humeral canal is not violated during the surgical procedures disclosed herein, reducing blood loss and marrow-fat emboli release into the blood. The canal is also preserved for future stemmed arthroplasty components if revision surgery is ever required. This does not apply in the case of the long stem example.

The undersurface design resulting from overlapping planar bone cuts provides resistance to rotational forces and is potentially more stable than a single flat cut. This may provide for improved long-term stability of the component. By making multiple oblique cuts through the humeral head surface, a greater proportion of the component will be resting again the strong outer cortical bone of the humerus than a standard hemispherical prosthesis.

The present design does not require or reference the humeral canal to determine proper location for bone cuts, thus the surgeon is free to position the humeral component to best fit each patient's' individual anatomy. This is even more important in cases where deformity has altered the normal shape of the humerus.

The articular surface of the humeral prosthesis can be ellipsoid to better match the normal anatomy of the humerus. Current stemmed and resurfacing arthroplasty designs, due to the variable-offset feature of stemmed designs and the bone preparation process of resurfacing designs, include only spherical humeral heads.

The most inferior circle of the prosthesis extends inferiorly to cover the most medial aspect of the medial humeral neck bone, in order to reduce the incidence of impingement of the medial humerus against a glenoid prosthetic component.

Retrieval studies of failed glenoid components have shown that inferior impingement is a significant contributor to glenoid loosening.

By placing the prosthesis more precisely in a location that better replicates the normal anatomy, motion across the glenohumeral joint may be more smooth and stable, and eccentric forces placed upon the glenoid prosthesis may be reduced.

The current prosthesis can be finely adjusted by varying the size, angle and relative location of each individual circle of a sphere relative to the other circles. This allows the prosthesis to be altered in discrete regions for clinical purposes.

Other objectives and advantages of this technology will become apparent from the following description taken in conjunction with the accompanying drawings wherein are set forth, by way of illustration and example, certain embodiments of the technology. The drawings contained herein constitute a part of this specification and include exemplary embodiments of the present technology and illustrate various objects and features thereof.

Referring to FIGS. **1A-1F**, a humeral component **100** includes an articular surface **102** and a bone-facing side **104** which is opposite to the articular surface.

The humeral component **100** has a smooth, polished articular bearing surface **102** which may articulate with a natural glenoid socket or a glenoid prosthetic component. The glenoid prosthetic component may be of the type disclosed in U.S. Provisional Patent Application No. 61/776,398, filed Mar. 11, 2013, and entitled OBLIQUE-INSERTION ANCHORING MECHANISM FOR GLENOID PROSTHETIC COMPONENT; or the type disclosed in U.S. patent application Ser. No. 14/042,258, filed Sep. 30, 2013, and entitled GLENOID ARTHROPLASTY. The contents of these documents are incorporated herein by reference. The glenoid component may be polyethylene or another biocompatible material.

The prosthetic humeral component may be designed as multiple overlapping circles of a sphere, where the sphere forms the articular surface **102**. A "circle of a sphere" is a circle defined by the intersection of a sphere and a plane. If the plane contains the center of the sphere, then the circle is called a "great circle"; otherwise, it is a "small circle." A "spherical cap" is a three-dimensional portion of a sphere cut off by an intersecting plane. If the plane passes through the center of the sphere, the spherical cap is called a "hemisphere." If the height of the spherical cap is less than the radius of the sphere, the spherical cap is called a "minor spherical cap." If the height of the spherical cap is greater than the radius of the sphere, the spherical cap is called a "major spherical cap." In this specification, any reference to a circle of a sphere is also a reference to the corresponding spherical cap, and any reference to a spherical cap is also a reference to the corresponding circle of the sphere.

Together these overlapping circles of a sphere, and corresponding spherical caps, form an articular surface which is nearly hemispherical, or partly spherical, but with significantly less volume of material than a solid hemisphere due to the multiple planar surfaces on the bone facing side **104**, which in a solid hemisphere would be flat. The articular surface area created by the overlapping circles of a sphere nearly covers the native articular surface of the proximal humerus. Referring to FIG. **1A**, each one of the planar surfaces corresponds to one of the overlapping circles of a sphere or spherical caps. All of the spherical surfaces are co-radial; they share the same spherical center and all spherical radii are equal, so that the articular surface **102** is an uninterrupted spherical surface. Some examples of the present technology utilize four overlapping circles of a sphere, but other examples may have three, five or more overlapping circles of a sphere.

In an alternate version of the technology, the prosthetic humeral component **100** may have an ellipsoid or ovoid articular surface **102**, rather than a spherical articular surface. The circles of an ellipsoid or ovoid, and the corresponding caps, may be overlapped to create the same effect of covering a similar amount of surface area with a reduced volume of material. The ellipsoid or ovoid articular surface has a first radius (or first diameter) in a first plane or along a first axis which is dimensionally different from a second radius (or second diameter) in a second plane or along a second axis. The first radius may be larger or smaller than the second radius. Referring to FIGS. **1C**, **1E**, and **1F**, the radius of articular surface **102** in FIG. **1C** may be dimensionally different from the radius of articular surface **102** in FIG. **1F** when the articular surface **102** is ellipsoid or ovoid instead of spherical. For example, an ellipsoid or ovoid articular surface may have a larger diameter along the superior-inferior axis in the coronal plane than in the transverse plane, or vice versa. The increased radius of curvature of an ellipsoid or ovoid bearing surface in a given direction may reduce the constraint of the humeral head within the glenohumeral joint in that direction. This reduced constraint may result in reduced eccentric forces applied to the bearing surface and reduced risk of implant loosening. The increased radius of curvature may be oriented relative to the prevailing direction of articulation of a given joint, or relative to an articulation direction in which impingement, loosening, or other stress-related effects are known to occur. These ellipsoid or ovoid shapes may also be narrower at the superior end and broader at the inferior end. The ellipsoid or ovoid shape may better replicate the normal articular surface of the humeral head, better replicating the kinematics of the shoulder during articulation, and better matching the morphology of the natural articulating surface, allowing for better fit and transition between the implant and the bone, at least in some patients.

Humeral components according to the present technology may also be designed as a hemisphere, spherical cap, ellipsoid cap, or ovoid cap with a tapered polygonal socket forming the bone-facing side. The tapered polygonal socket may be designed by extruding a polygonal shape from the flat side of the hemisphere or cap toward the articular surface while tapering the sides of the polygonal shape inward. The polygonal shape may be a triangle, square, rectangle, pentagon, or other polygonal shape, and may be regular or irregular, and may be symmetrically or asymmetrically disposed relative to the center of the hemisphere or cap. The sides of the polygonal shape may all have the same taper angle, although one or more sides may have a different taper angle. It can be appreciated that the bone-facing side **104** of humeral component **100** may be designed as a tapered rectangular socket, and similarly for humeral components **200**, **300**, **400**, **500**, **600** discussed below.

Humeral component **100** may include four planar surfaces **120**, **122**, **124**, **126** in a concave arrangement in which the planar surfaces converge together as they approach the middle of the articular surface **102**, as seen best in FIG. **1A**. Other examples may include three, five, or more planar surfaces in a concave arrangement. More specifically, one example may include planar surfaces **120**, **122**, **124**. The planar surfaces diverge as they extend away from the middle of the articular surface **102**, and intersect the articular surface to establish an articular margin **106** around a perimeter of the humeral component **100**. The articular margin may be described as scalloped or having one or more indentations

129. Each one of the planar surfaces intersects each other planar surface at an obtuse angle, although right angles and acute angles are also contemplated. Planar surfaces **120**, **124** intersect along a line **119**, planar surfaces **120**, **126** intersect along a line **121**, planar surfaces **120**, **122** intersect along a line **123**, planar surfaces **124**, **126** intersect along a line **125**, and planar surfaces **124**, **122** intersect along a line **127**. The lines **119**, **121**, **123**, **125**, **127** may also be referred to as intersections, edges, or internal corners, and may include fillet radii, as best seen in FIG. **1**E. Referring to FIG. **1**E, lines **119**, **123**, **127** intersect at a first point **111**; and lines **119**, **121**, **125** intersect at a second point **113**. Lines **123**, **121** and **127**, **125** also intersect when extended. Line **119** in this example may extend in a superior-inferior direction when the humeral component **100** is implanted.

The humeral component **100** may have a roughened or porous bone-facing side **104**, or undersurface, which rests on the prepared bone of the humerus when the humeral component is implanted. These roughened or porous surfaces assist in bony apposition between the implant and the underlying subcondylar bone encouraging bony ingrowth into the porosity of the bone-facing side once the humeral component is implanted. From this undersurface or bone-facing side **104**, at least one anchoring element **128** projects outwardly; the example shown includes three anchoring elements **128**, **130**, **132**. The anchoring elements project into the humeral bone when the humeral component is implanted, and may anchor the humeral component to prevent loosening or micromotion. The anchoring elements may be pegs which are round, cruciate, or have fins, or have another cross sectional shape for bone fixation. The anchoring elements may include fenestrations. Some of the examples disclosed herein utilize three pegs, but the number of pegs may vary. The pegs may be parallel, converging, diverging, or skew. The pegs may be smooth, matte, rough, or porous to promote bone cement fixation or bone ingrowth. The illustrated anchoring elements **128**, **130**, **132** are cylindrical and parallel to one another. Anchoring element **128** is longer than anchoring elements **130**, **132**, and may therefore be suited for implantation in an inferior aspect of the humeral head/neck.

Humeral component **100** is bilaterally symmetric about a plane through line **119**, and may therefore be implanted in right or left shoulders. Humeral component **100** may be implanted so that planar surface **126** covers a superior aspect of the humeral head, planar surface **122** covers an inferior aspect of the humeral head, planar surfaces **120** and **124** cover anterior and posterior portions of the humeral head, anchoring element **128** extends through the inferior aspect of the humeral head and optionally into the humeral neck, and anchoring elements **130**, **132** extend into anterior and posterior portions of the humeral head. The outer portion, or rim, of planar surface **126** faces at least a portion of the rotator cuff, and, because planar surface **126** is indented to form the indentation **129** along the articular margin **106**, a space exists between the rim of planar surface **126** and the rotator cuff. This space provides relief, or room, for the rotator cuff to function without excessively rubbing against the outer portion, or rim, of the humeral component **600**, thus reducing the risk of rotator cuff damage.

In one example, the inferior-most peg may be curved and elongated, forming a stem which extends distally into the diaphysis of the humerus, following the curve of the medial neck of the humerus. This inferior peg or stem may be manufactured as one piece with the bearing surface component, or the peg or stem may be modular, supplied in varying thickness and lengths. A modular peg may be attached to the bearing portion of the component via a Morse taper, screw-in or other connection mechanism.

In another embodiment, the location of the pegs on the backside of the prosthetic component may project in a more vertical direction. This embodiment may be suitable for a surgeon utilizing a subscapularis-preserving surgical technique where the only exposure to the humerus is from the superior direction.

The prosthesis may be fixed in place with bone cement, or it may have a roughened surface or porous coating on the undersurface for cementless (press-fit) use.

The entire humeral component **100** may be made of a solid metal piece. In other examples, the prosthesis may be made of another material, such as any of the materials commonly used in orthopaedic joint arthroplasty, such as ceramic, composite, polyethylene or pyrocarbon. Combinations of materials may also be used.

Referring to FIGS. **2**A-**2**F, another humeral component **200** includes an articular surface **202** and a bone-facing side **204** which is opposite to the articular surface. Humeral component **200** includes the following features, which may be substantially similar to, or the same as, the corresponding features of humeral component **100**: planar surfaces **220**, **222**, **224**, **226**; lines **219**, **221**, **223**, **225**, **227**; points **211**, **213**; and anchoring elements **228**, **230**, **232**. In an alternate version of the technology, the prosthetic humeral component **200** may have an ellipsoid or ovoid articular surface **202**, rather than a spherical articular surface. The planar surfaces **220**, **222**, **224**, **226** are in a concave arrangement in which the planar surfaces converge together as they approach the middle of the articular surface **202**, as seen best in FIG. **2**A. Each one of the planar surfaces intersects each other planar surface at an obtuse angle, although right angles and acute angles are also contemplated. Fillet radii are present along lines **221**, **225** and absent along lines **219**, **223**, **227**. The illustrated anchoring elements **228**, **230**, **232** are cylindrical and parallel to one another. These anchoring elements include bilateral longitudinal grooves **236**. Anchoring element **228** is longer than anchoring elements **230**, **232**, and may therefore be suited for implantation in an inferior aspect of the humeral head/neck.

Humeral component **200** is bilaterally symmetric about a plane through line **219**, and may therefore be implanted in right or left shoulders. Humeral component **200** may be implanted so that planar surface **226** covers a superior aspect of the humeral head, planar surface **222** covers an inferior aspect of the humeral head, planar surfaces **220** and **224** cover anterior and posterior portions of the humeral head, anchoring element **228** extends through the inferior aspect of the humeral head and optionally into the humeral neck, and anchoring elements **230**, **232** extend into anterior and posterior portions of the humeral head.

Referring to FIGS. **3**A-**3**F, yet another humeral component **300** includes an articular surface **302** and a bone-facing side **304** which is opposite to the articular surface. Humeral component **300** includes the following features, which may be substantially similar to, or the same as, the corresponding features of humeral component **100**: planar surfaces **320**, **322**, **324**, **326**; lines **319**, **321**, **323**, **325**, **327**; fillet radii; points **311**, **313**; and anchoring elements **328**, **330**, **332**. In an alternate version of the technology, the prosthetic humeral component **300** may have an ellipsoid or ovoid articular surface **302**, rather than a spherical articular surface. The planar surfaces **320**, **322**, **324**, **326** are in a concave arrangement in which the planar surfaces converge together as they approach the middle of the articular surface **302**, as seen best in FIG. **3**A. Each one of the planar surfaces intersects each other planar surface at an obtuse angle, although right angles and acute angles are also contemplated. The illustrated anchoring elements **330**, **332** are cylindrical and parallel to one another. Anchoring element **328** is curved outwardly, and is longer than anchoring elements **330**, **332**, and may therefore be suited for implantation in an inferior aspect of the humeral head/neck. Anchoring element **328** also includes four longitudinal grooves **336**, which are evenly arranged around anchoring element **328**. Anchoring element **328** may be described as having a diamond-shaped or star-shaped cross section.

Humeral component **300** is bilaterally symmetric about a plane through line **319**, and may therefore be implanted in right or left shoulders. Humeral component **300** may be implanted so that planar surface **326** covers a superior aspect of the humeral head, planar surface **322** covers an inferior aspect of the humeral head, planar surfaces **320** and **324** cover anterior and posterior portions of the humeral head, anchoring element **328** extends through the inferior aspect of the humeral head and optionally into the humeral neck, and anchoring elements **330**, **332** extend into anterior and posterior portions of the humeral head.

Referring to FIGS. **4**A-**4**B, yet another humeral component **400** includes an articular surface **402** and a bone-facing side **404** which is opposite to the articular surface. Humeral component **400** includes the following features, which may be substantially similar to, or the same as, the corresponding features of humeral component **100**: planar surfaces **420**, **422**, **424**, **426**; lines **419**, **421**, **423**, **425**, **427**; fillet radii; points **411**, **413**; and anchoring elements **428**, **430**, **432**. In an alternate version of the technology, the prosthetic humeral component **400** may have an ellipsoid or ovoid articular surface **402**, rather than a spherical articular surface. The planar surfaces **420**, **422**, **424**, **426** are in a concave arrangement in which the planar surfaces converge together as they approach the middle of the articular surface **402**, as seen best in FIG. **4**A. The planar surfaces diverge as they extend away from the middle of the articular surface **402**, and intersect the articular surface to establish an articular margin **406** around a perimeter of the humeral component **400**. The articular margin may be described as scalloped or having one or more indentations **429**. Each one of the planar surfaces intersects each other planar surface at an obtuse angle, although right angles and acute angles are also contemplated. Planar surface **426** has a smaller area than planar surface **422**, and may be described as being indented, or centrally offset, particularly in comparison to planar surface **422**. Humeral component **400** includes a fourth anchoring element **434**. The illustrated anchoring elements **428**, **430**, **432**, **434** are cylindrical and parallel to one another. Anchoring elements **428**, **430**, **432**, **434** also include bilateral longitudinal grooves **436**.

Humeral component **400** is bilaterally symmetric about a plane through line **419**, and may therefore be implanted in right or left shoulders. Humeral component **400** may be implanted so that planar surface **426** covers a superior aspect of the humeral head, planar surface **422** covers an inferior aspect of the humeral head, planar surfaces **420** and **424** cover anterior and posterior portions of the humeral head, anchoring element **428** extends through the inferior aspect of the humeral head and optionally into the humeral neck, anchoring elements **430**, **432** extend into anterior and posterior portions of the humeral head, and anchoring element **434** extends into the superior aspect of the humeral head. The outer portion, or rim, of planar surface **426** faces at least a portion of the rotator cuff, and, because planar surface **426** is indented to form the indentation **429** along the articular margin **406**, a space exists between the rim of planar surface **426** and the rotator cuff. This space provides relief, or room, for the rotator cuff to function without excessively rubbing against the outer portion, or rim, of the humeral component **600**, thus reducing the risk of rotator cuff damage.

Referring to FIGS. **5**A-**5**B, yet another humeral component **500** includes an articular surface **502** and a bone-facing side **504** which is opposite to the articular surface. Humeral component **500** includes the following features, which may be substantially similar to, or the same as, the corresponding features of humeral component **100**: planar surfaces **520**, **522**, **524**, **526**; lines **519**, **521**, **523**, **525**, **527**; fillet radii; points **511**, **513**; and anchoring elements **528**, **530**, **532**. In an alternate version of the technology, the prosthetic humeral component **500** may have an ellipsoid or ovoid articular surface **502**, rather than a spherical articular surface. The planar surfaces **520**, **522**, **524**, **526** are in a concave arrangement in which the planar surfaces converge together as they approach the middle of the articular surface **502**, as seen best in FIG. **5**A. The planar surfaces diverge as they extend away from the middle of the articular surface **502**, and intersect the articular surface to establish an articular margin **506** around a perimeter of the humeral component **500**. The articular margin may be described as scalloped or having one or more indentations **529**. Each one of the planar surfaces intersects each other planar surface at an obtuse angle, although right angles and acute angles are also contemplated. Planar surface **526** has a smaller area than planar surface **522**, and may be described as being indented, or centrally offset, particularly in comparison to planar surface **522**. Humeral component **500** includes a fourth anchoring element **534**. The illustrated anchoring elements **528**, **530**, **532**, **534** are cylindrical and parallel to one another. Anchoring element **528** may be longer than anchoring elements **530**, **532**, **534**. Anchoring elements **528**, **530**, **532**, **534** also include bilateral longitudinal grooves **536**.

Humeral component **500** is bilaterally symmetric about a plane through line **519**, and may therefore be implanted in right or left shoulders. Humeral component **500** may be implanted so that planar surface **526** covers a superior aspect of the humeral head, planar surface **522** covers an inferior aspect of the humeral head, planar surfaces **520** and **524** cover anterior and posterior portions of the humeral head, anchoring element **528** extends through the inferior aspect of the humeral head and optionally into the humeral neck, anchoring elements **530**, **532** extend into anterior and posterior portions of the humeral head, and anchoring element **534** extends into the superior aspect of the humeral head. The outer portion, or rim, of planar surface **526** faces at least a portion of the rotator cuff, and, because planar surface **526** is indented to form the indentation **529** along the articular margin **506**, a space exists between the rim of planar surface **526** and the rotator cuff. This space provides relief, or room, for the rotator cuff to function, thus reducing the risk of rotator cuff damage.

Referring to FIGS. **6**A-**6**Q, yet another humeral component **600** includes an articular surface **602** and a bone-facing side **604** which is opposite to the articular surface. Humeral component **600** includes the following features, which may be substantially similar to, or the same as, the corresponding features of humeral component **100**: planar surfaces **620**, **622**, **624**, **626**; lines **619**, **621**, **623**, **625**, **627**; fillet radii; points **611**, **613**; and anchoring elements **628**, **630**, **632**. In an alternate version of the technology, the prosthetic humeral component **600** may have an ellipsoid or ovoid articular surface **602**, rather than a spherical articular surface. The planar surfaces **620**, **622**, **624**, **626** are in a concave arrangement in which the planar surfaces converge together as they approach the middle of the articular surface **602**, as seen best in FIG. **6**A.

The planar surfaces diverge as they extend away from the middle of the articular surface **602**, and intersect the articular surface to establish an articular margin **606** around a perimeter of the humeral component **600**. The articular margin may be described as scalloped or having one or more indentations **629**. Each one of the planar surfaces intersects each other planar surface at an obtuse angle, although right angles and acute angles are also contemplated. Planar surface **626** has a smaller area than planar surface **622**, and may be described as being indented, or centrally offset, particularly in comparison to planar surface **622**. Humeral component **600** includes a fourth anchoring element **634** and a conical surface **674**. The illustrated anchoring elements **628**, **630**, **632**, **634** are cylindrical and parallel to one another. Anchoring element **628** may be longer than anchoring elements **630**, **632**, **634**. Anchoring element **634** may be shorter than anchoring elements **628**, **630**, **632**. Anchoring elements **628**, **630**, **632**, **634** also include bilateral longitudinal grooves **636**. The conical surface **674** is present around an outermost portion of the bone-facing side **604**, and is best seen in FIG. **6**D in the vicinity of the outermost portions of lines **621**, **623**, **625**, **627**.

Humeral component **600** is bilaterally symmetric about a plane through line **619**, and may therefore be implanted in right or left shoulders. Humeral component **600** may be implanted so that planar surface **626** covers a superior aspect of the humeral head, planar surface **622** covers an inferior aspect of the humeral head, planar surfaces **620** and **624** cover anterior and posterior portions of the humeral head, anchoring element **628** extends through the inferior aspect of the humeral head and optionally into the humeral neck, anchoring elements **630**, **632** extend into anterior and posterior portions of the humeral head, and anchoring element **634** extends into the superior aspect of the humeral head. The outer portion, or rim, of planar surface **626** faces at least a portion of the rotator cuff, and, because planar surface **626** is indented to form the indentation **629** along the articular margin **606**, a space exists between the rim of planar surface **626** and the rotator cuff. This space provides relief, or room, for the rotator cuff to function, thus reducing the risk of rotator cuff damage.

FIGS. **6**F and **6**G illustrate humeral component **600** in cross sectional views. In each view, two additional smaller size humeral components **600'**, **600"** are superimposed on humeral component **600** to show certain aspects of the design rationale governing the progression from one size to the next. The illustrated design rationale may apply to any of the humeral components disclosed herein. If humeral component **600** is referred to as a large size, then humeral component **600'** is a medium size, and humeral component **600"** is a small size. However, these small, medium, and large size designations are for the purposes of illustration only. It is understood that a full size range of humeral components may include more than three sizes, including sizes larger than humeral component **600**, sizes smaller than humeral component **600"**, and/or sizes in between those illustrated herein.

The superimposed cross sections of humeral components **600**, **600'**, **600"** reveal that the planar surfaces **620**, **622**, **624**, **626**; lines **619**, **621**, **623**, **625**, **627**; fillet radii; points **611**, **613**; anchoring elements **628**, **630**, **632**, **634**, and conical surface **674** are all identical among the three different sizes. In other words, the same bone preparation—saw cuts, drilled holes, and conical ream—may be performed for all humeral component sizes, and any size humeral component may be implanted onto a particular prepared humerus.

The superimposed cross sections of humeral components **600**, **600'**, **600"** also show that the various articular surfaces **602**, **602'**, **602"** are neither concentric nor tangent. Instead, each articular surface **602**, **602'**, **602"** passes through a defined circle **603**, which appears as a pair of points **603** in each FIGS. **6**F and **6**G. This defined circle **603** may be thought of as a gage circle which has a fixed relationship to the features of the bone-facing side **604**. The defined circle may lie in the same plane as line **619**, for example, or planar surfaces **744**, **844** described below. The articular surface **602"** of the small humeral component **600"** protrudes farther above the circle **603** than do the articular surfaces **602'**, **602** of the medium and large humeral components **600'**, **600**. Later in this specification, it will be shown that this defined circle **603** may correspond to a depth stop feature on a planar reamer.

Referring to FIGS. **7**A-**7**F, yet another humeral component **700** includes an articular surface **702** and a bone-facing side **704** which is opposite to the articular surface. The articular surface is smooth and polished, and may be spherical, elliptical, or ovoid. Humeral component **700** may be designed with four overlapping circles of a sphere, or as a hemisphere with a tapered, triangular, flat-bottom socket forming the bone-facing side.

Humeral component **700** may include four planar surfaces **744**, **762**, **764**, **766** in a concave arrangement in which the planar surfaces **762**, **764**, **766** converge together as they approach the middle of the articular surface **702** and the planar surface **744**, as seen best in FIG. **7**A. Other examples may include three, five, or more planar surfaces in a concave arrangement. Each one of the planar surfaces intersects each other planar surface at an obtuse angle, although right angles and acute angles are also contemplated. Planar surfaces **744**, **762** intersect along a line **757**, planar surfaces **744**, **764** intersect along a line **759**, and planar surfaces **744**, **766** intersect along a line **761**. Planar surfaces **762**, **764**; **764**, **766**; and **766**, **762** also intersect when extended. The lines **757**, **759**, **761** may also be referred to as intersections, edges, or internal corners, and may include fillet radii, as best seen in FIG. **7**D. Referring to FIG. **7**D, lines **757**, **759** intersect at a first point **711**; lines **759**, **761** intersect at a second point **713**; and lines **757**, **761** intersect at a third point **715**. Humeral component **700** also includes a conical surface **774**, which is present in the vicinity of the outermost portions of lines **757**, **759**, **761**, as best seen in FIG. **7**D.

The humeral component **700** may have a roughened bone-facing side **704**, or undersurface, which rests on the prepared bone of the humerus when the humeral component is implanted. From this undersurface or bone-facing side **704**, at least one anchoring element **768** projects outwardly. The example shown includes three anchoring elements **768**, **770**, **772** protruding from planar surfaces **762**, **764**, **766**, respectively. The anchoring elements project into the humeral bone when the humeral component is implanted, and may anchor the humeral component to prevent loosening or micromotion. The anchoring elements may be pegs which are round, cruciate, or have fins, or have another cross sectional shape for bone fixation. The anchoring elements may include fenestrations. Some of the examples disclosed herein utilize three pegs, but the number of pegs may vary. The pegs may be parallel, converging, diverging, or skew. The pegs may be smooth, matte, rough, or porous to promote bone cement fixation or bone ingrowth. The illustrated anchoring elements **768**, **770**, **772** are cylindrical and parallel to one another.

Humeral component **700** is bilaterally symmetric about a plane through section line **7**F-**7**F of FIG. **7**D, and trilaterally symmetric about an axis normal to planar surface **744**. Humeral component **700** may therefore be implanted in right or left shoulders. Humeral component **700** may be implanted so that planar surface **764** covers an inferior aspect of the humeral head, planar surfaces **762** and **766** cover anterior-superior and posterior-superior portions of the humeral head, anchoring element **770** extends through the inferior aspect of the humeral head and optionally into the humeral neck, and anchoring elements **768**, **772** extend into anterior and posterior portions of the humeral head. However, due to its trilateral symmetry, humeral component **700** may also be implanted so that planar surface **762** or planar surface **766** covers the inferior aspect of the humeral head instead of planar surface **764**.

Referring to FIGS. **8**A-**8**D, yet another humeral component **800** includes an articular surface **802** and a bone-facing side **804** which is opposite to the articular surface.

Humeral component **800** includes the following features, which may be substantially similar to, or the same as, the corresponding features of humeral component **700**: planar surfaces **844**, **862**, **864**, **866**; lines **857**, **859**, **861**; points **811**, **813**, **815**; conical surface **874**; anchoring elements **868**, **870**, **872**. In an alternate version of the technology, the prosthetic humeral component **800** may have an ellipsoid or ovoid articular surface **802**, rather than a spherical articular surface. The planar surfaces **844**, **862**, **864**, **866** are in a concave arrangement in which the planar surfaces **862**, **864**, **866** converge together as they approach the middle of the articular surface **802** and the planar surface **844**, as seen best in FIG. **8**A. Each one of the planar surfaces intersects each other planar surface at an obtuse angle, although right angles and acute angles are also contemplated. Planar surfaces **862**, **864** intersect along a line **863**, planar surfaces **864**, **866** intersect along a line **865**, and planar surfaces **862**, **866** intersect along a line **867**. No fillet radii are shown in this example. The illustrated anchoring elements **868**, **870**, **872** are cylindrical and parallel to one another. Anchoring element **870** also includes four longitudinal grooves **876** which are equally spaced around the anchoring element. Anchoring element **870** may be described as having a cruciate or plus-shaped cross section. Humeral component **800** includes a planar surface **878**, which is present in the vicinity of the outermost portions of planar surfaces **862**, **864**, **866**, as best seen in FIG. **8**A. Planar surface **878** may be parallel to planar surface **844**.

Humeral component **800** is bilaterally symmetric about a plane through section line **8**C-**8**C of FIG. **8**B, and trilaterally symmetric about an axis normal to planar surface **844**. Humeral component **800** may therefore be implanted in right or left shoulders. Humeral component **800** may be implanted so that planar surface **864** covers an inferior aspect of the humeral head, planar surfaces **862** and **866** cover anterior-superior and posterior-superior portions of the humeral head, anchoring element **870** extends through the inferior aspect of the humeral head and optionally into the humeral neck, and anchoring elements **868**, **872** extend into anterior and posterior portions of the humeral head. However, due to its trilateral symmetry, humeral component **800** may also be implanted so that either planar surface **862** or **866** covers the inferior aspect of the humeral head instead of planar surface **864**.

Referring to FIG. **9**A, a guide wire or pin **900** and a template **1000** are shown in an operative arrangement. The template **1000** may be used to establish the desired orientation of the implanted humeral component relative to the intact proximal humeral anatomy, and may guide insertion of the pin **900** into the humeral head. The desired orientation of the humeral component may relate to an axis which is normal to a central portion of the intact articular surface of the humeral head, or parallel to the intact humeral neck axis.

The pin **900** is a slender elongated shaft **902** which extends between a proximal end **904** and a distal tip **906**. The shaft **902** may be circular in cross-section as shown, or non-circular in cross-section. The proximal end **904** may include a torque connector for connection to a T-handle, drill, or other torque source. The distal tip **906** may be threaded, fluted for cutting, pointed, faceted as in a trocar tip, rounded, or blunt.

Referring to FIGS. **9**A-**9**B, the template **1000** includes a shaft **1002** which extends between a proximal end **1004** and a distal working portion **1006**. The proximal end **1004** may include a handle or a coupling. The working portion **1006** includes a round perimeter rim **1008** which may be connected to the shaft **1002** by one or more arms **1010**. The example shown includes bilateral straight arms **1010**, **1012** interposed between bilateral bifurcated arms **1014**, **1016**. One or more apertures **1018** may extend between the arms; six apertures **1018** are shown in the example. The working portion **1006** has a bone-facing side **1020** and an opposite side **1022**. The bone-facing side may be concave as shown, convex, or flat. The opposite side **1022** may complement the bone-facing side **1020**. One or more projections **1024** may extend from the rim **1008**; three projections **1024**, **1026**, **1028** are shown, equally spaced around the rim **1008**. The shaft **1002** may include a central cannulation **1030** which receives the pin **900**.

Referring to FIG. **28**, an alignment guide **1100** is shown in use with the pin **900** and the template **1000** relative to a simplified humeral head **40**. The alignment guide **1100** may provide additional anatomical referencing beyond that provided by the template **1000**, in order to set the desired orientation of the implanted humeral component relative to the intact proximal humeral and forearm anatomy.

The alignment guide **1100** includes a shaft **1102** which extends between a proximal handle **1104** and a distal working portion **1106**. In use, the shaft **1102** is aligned with the patient's forearm in consideration of aligning the pin **900** in the desired rotational anteversion and retroversion of the patient. The working portion **1106** includes a plate **1108** and at least one socket **1110** for releasably or permanently coupling to the shaft **1102**. The plate **1108** may include a humeral shaft extension **1112**, an articular bar **1114**, and a post **1116**. The articular bar **1114** may cross the humeral shaft extension **1112** at an oblique angle to form a "T" shape. The post **1116** may extend perpendicular to the articular bar **1114** opposite the humeral shaft extension **1112**. The socket **1110** may be located in the area where the articular bar **1114** crosses the humeral shaft extension **1112**. The working portion **1106** may include a second socket (not visible in FIG. **28**) on an opposite side of the plate **1108** from the socket **1110**. The shaft **1102** may be releasably coupled to either socket to provide configurations suitable for right or left shoulder procedures.

Referring to FIGS. **10**A-**10**B, the pin **900** and a planar reamer **1400** are shown in an operative arrangement. The planar reamer **1400** may be used to cut a planar bone resection **44** which is perpendicular to the axis of the pin **900** and which may have an outer diameter corresponding to the defined circle **603**. The bone resection **44** may correspond to planar surfaces **744**, **844**, or it may correspond to lines **119**, **219**, **319**, **419**, **519**, **619**.

The planar reamer **1400** includes a shaft **1402** which extends between a proximal end **1404** and a distal working portion **1406**. The proximal end **1404** may include a handle or a coupling; a torque coupling **1405** is shown for coupling the planar reamer **1400** to a T-handle, drill, or other torque driver. The working portion **1406** includes a round perimeter rim **1408** which may be connected to the shaft **1402** by one or more arms **1410**. The example shown includes bilateral arms **1410**, **1412**. One or more apertures **1418** may extend between the arms; two apertures are shown in the example. The working portion **1406** has a bone-facing side **1420** and an opposite side **1422**. The bone-facing side **1420** is flat. Cutting features **1424** are present on the bone-facing side **1420**. In this example, the cutting features **1424** include a series of alternating teeth **1426** and grooves **1428** with concentric circular patterns of crossing grooves **1429**, which may be referred to as chip breakers. Relief channels **1432** may be included around the outer portion of each arm **1410**, **1412** to provide clearance for the tools used to fabricate the cutting features **1424** and/or to delimit an outer diameter of the cutting features. A continuous smooth planar surface **1434** extends completely around the perimeter rim **1408** on the bone-facing side **1420**, forming a boundary within which all of the cutting features **1424** are contained. The surface **1434** may be coplanar with the cutting features **1424**, for example the peaks of the teeth **1426** or the valleys of the grooves **1428**. Alternatively, the surface **1434** may lie above or below the cutting features. The surface **1434** functions as a depth stop in use, as will be described later. An inner edge **1436** of the surface **1434**, excluding any interruption caused by the relief channels **1432**, may correspond to the defined circle **603** described above. The opposite side **1422** may complement the bone-facing side **1420**. The shaft **1402** may include a central cannulation **1430** which receives the pin **900**.

Another example of a planar reamer has a plurality of arms that extend radially from the shaft to the rim like spokes on a wheel. This example may or may not have the continuous smooth planar surface that extends completely around the perimeter rim on the bone-facing side. This example may have one or more radially extending cutting teeth per arm. Because this example has through openings between the cutting teeth, the bone and articular cartilage fragments are more easily cleared and the reamer is less likely to clog while reaming.

Referring to FIGS. **11A-11B**, a conical reamer **1500** includes a shaft **1502** which extends between a proximal end **1504** and a distal working portion **1506**. The conical reamer **1500** may be used to cut a conical bone resection **74** which corresponds to conical surface **674**, **774**, **874**. The proximal end **1504** may include a handle or a coupling; a blunt proximal end is shown. The working portion **1506** includes a round perimeter rim **1508** which may be connected to the shaft **1502** by one or more arms **1510**. The example shown includes a plurality of radially extending arms **1510**. One or more apertures **1518** may extend between the arms; a plurality of apertures is shown in the example. However, a roughened file-like tissue-cutting surface may also extend the working portion **1506** allowing rasp-like tissue removal. The working portion **1506** has a bone-facing side **1520** and an opposite side **1522**. The bone-facing side includes a conical surface **1512** surrounding a central planar surface **1514** which is perpendicular to the shaft **1502**. Cutting features **1524** are present on the bone-facing side. In this example, the cutting features **1524** include a series of radial teeth **1526** on the leading side of each arm **1510** (depending on the direction of rotation, clockwise or counterclockwise). A relief channel **1532** may be included between the central planar surface **1514** and the conical surface **1512**. The planar surface **1514** functions as a depth stop in use, as will be described later. The opposite side **1522** may complement the bone-facing side **1520**. The shaft **1502** may include a central cannulation **1530** which receives the pin **900**.

Specific preparations of the proximal humeral bone surface are disclosed in order to accommodate the multi-planar undersurfaces of the prosthetic components so the undersurfaces rests flush against the bone. The proximal humeral bone may be prepared with the use of a cutting guide which rests on the head of the humerus. The cutting guide has slots which guide a cutting tool such as an oscillating saw blade to make bone cuts corresponding to the particular design of the undersurface of the humeral prosthesis. The humeral cutting guide may be designed to be used by a surgeon utilizing a standard subscapularis tenotomy or lesser tuberosity osteotomy, but may also be adapted to a surgeon utilizing a subscapularis-preserving technique. Various cutting guides will now be described.

Referring to FIGS. **12A-12J**, a cutting guide **1600** may be referred to as a cut and drill guide or as an all in one guide. The cutting guide **1600** may be used to guide a cutting tool, such as a saw blade, to cut four planar bone resections **20**, **22**, **24**, **26** corresponding to planar surfaces **120**, **122**, **124**, **126** of humeral component **100**, or the planar surfaces of humeral components **200**, **300**, **400**, **500**, **600**. The cutting guide **1600** may also be used to guide a cutting tool, such as a drill or reamer, to cut bone holes **28**, **30**, **32** corresponding to anchoring elements **128**, **130**, **132** of humeral component **100**, or the anchoring elements of humeral components **200**, **300**, **400**, **500**, **600**. The cutting guide **1600** may also serve the function of the template **1000**.

The cutting guide **1600** includes a cylindrical body **1608** terminating at one end in a spherical shell or cup **1610**. The cutting guide **1600** has a bone-facing side **1609** which includes the perimeter rim and concave interior of the spherical cup **1610**. Three holes **1628**, **1630**, **1632** extend lengthwise through the cutting guide **1600**, corresponding to the relative arrangement of anchoring elements **128**, **130**, **132** of humeral component **100**, or the anchoring elements of humeral components **200**, **300**, **400**, **500**, **600**. A fourth hole (not shown) may be included in the cutting guide **1600**, corresponding to anchoring elements **434**, **534**, **634** of humeral components **400**, **500**, **600**. One or more apertures **1612** may also extend lengthwise through the cutting guide **1600** to provide visualization windows and/or to reduce weight. Three apertures **1612**, **1613**, **1614** are shown in the example, interposed between the holes **1628**, **1630**, **1632**. Four slots **1620**, **1622**, **1624**, **1626** extend obliquely through the cutting guide **1600**, corresponding to the relative arrangement of planar surfaces **120**, **122**, **124**, **126** of humeral component **100**, or the planar surfaces of humeral components **200**, **300**, **400**, **500**, **600**. It will be appreciated that the number and arrangement of holes and/or slots in the illustrated cutting guide **1600** may be modified to correspond to the number and arrangement of anchoring elements and/or planar surfaces of humeral components **700**, **800**. One or more holes **1616** may extend through the cutting guide **1600** near the rim of the spherical cup **1610** to receive pins to fix the cutting guide **1600** to the humeral head prior to making any bone resections or holes; ten holes **1616**, **1646**, **1647**, **1648**, **1649**, **1650**, **1651**, **1652**, **1653**, **1654** are shown. Holes **1646**, **1647**, **1648**, **1651**, **1652**, **1653** are all parallel, and holes **1646**, **1653**; **1647**, **1652**; and **1648**, **1651** are coaxial. Referring to FIG. **12E**, one or more projections **1656** may extend from the interior of the spherical cup **1610** to engage the articular surface of the humeral head. The example shows three projections **1656**, **1657**, **1658**.

Referring to FIGS. **13A-13B**, a cutting guide **1800**, the pin **900**, and two fasteners **1890**, **1892** are shown in an operative arrangement. The cutting guide **1800** may be referred to as an anterior-posterior or A-P cutting guide or as a medial-lateral or M-L cutting guide. The cutting guide **1800** may be used to guide a cutting tool, such as a saw blade, to cut two planar bone resections **20**, **24** corresponding to planar surfaces **120**, **124** of humeral component **100**, or the planar surfaces of humeral components **200**, **300**, **400**, **500**, **600**.

The cutting guide **1800** includes a body **1808** with a bone-facing side **1809**. The bone-facing side **1809** includes a planar surface **1844**. Two slots **1820**, **1824** extend obliquely through the cutting guide **1800**, corresponding to the relative arrangement of planar surfaces **120**, **124** of humeral component **100**, or the planar surfaces of humeral components **200**, **300**, **400**, **500**, **600**. The slots **1820**, **1824** may intersect at the planar surface **1844**. One or more holes **1816** may extend through the cutting guide **1800** near opposing apices or ends of the body **1808** to receive fasteners **1890**, **1892** to fix the cutting guide **1800** to the humeral head prior to making any bone resections; two converging holes **1816**, **1846** are shown. A central hole **1818** may extend through the cutting guide **1800** to receive pin **900**.

Referring to FIGS. **14**A-**14**B, a cutting guide **1900** and two fasteners **1990**, **1992** are shown in an operative arrangement. The cutting guide **1900** may be referred to as an anterior-posterior or A-P cutting guide or as a medial-lateral or M-L cutting guide. The cutting guide **1900** may be used to guide a cutting tool, such as a saw blade, to cut two planar bone resections **20**, **24** corresponding to planar surfaces **120**, **124** of humeral component **100**, or the planar surfaces of humeral components **200**, **300**, **400**, **500**, **600**.

The cutting guide **1900** includes a shaft **1902** which extends between a proximal handle **1904** and a distal working portion **1906**. The distal working portion **1906** may be releasably or permanently coupled to the shaft **1902**. The distal working portion **1906** includes the following features, which may be substantially similar to, or the same as, the corresponding features of the cutting guide **1800**: body **1908**; bone-facing side **1909**; planar surface **1944**; slots **1920**, **1924**; and converging holes **1916**, **1946**. The slots **1920**, **1924** extend obliquely through the cutting guide **1900**, corresponding to the relative arrangement of planar surfaces **120**, **124** of humeral component **100**, or the planar surfaces of humeral components **200**, **300**, **400**, **500**, **600**. The slots **1920**, **1924** may intersect at the planar surface **1944**. A central socket or hole **1918** may receive shaft **1902**.

Referring to FIGS. **15**A-**15**B, a cutting guide **2000**, pin **900**, and four fasteners **2090**, **2092**, **2094**, **2096** are shown in an operative arrangement. The cutting guide **2000** may be referred to as a modular anterior-posterior or A-P cutting guide, or as a modular medial-lateral or M-L cutting guide. The cutting guide **2000** may be used to guide a cutting tool, such as a saw blade, to cut two planar bone resections **20**, **24** corresponding to planar surfaces **120**, **124** of humeral component **100**, or the planar surfaces of humeral components **200**, **300**, **400**, **500**, **600**.

The cutting guide **2000** includes a first body **2008** with a bone-facing side **2009**. The bone-facing side **2009** includes a planar surface **2044**. A slot **2020** extends obliquely through the first body **2008**, corresponding to the planar surface **120** of humeral component **100**, or the planar surface of humeral components **200**, **300**, **400**, **500**, **600**. One or more holes **2016** may extend through the first body **2008** near opposing apices or ends of the body to receive fasteners **2090**, **2092** to fix the first body **2008** to the humeral head prior to making any bone resections; two converging holes **2016**, **2046** are shown. A central hole **2018** may extend through the first body **2008** to receive pin **900**. The first body **2008** includes a protrusion **2010** which extends from the first body next to the slot **2020**. The protrusion **2010** may have a rectangular, notched, dovetail, or other cross sectional shape typical of a guide rail. A window **2011** or loop extends from the first body opposite the slot **2020**.

The cutting guide **2000** includes a rectangular second body **2012** with a slot **2014** that is complementary to the protrusion **2010** and sized for a clearance fit. The slot **2014** slidingly receives the protrusion **2010**. The second body **2012** includes a fastener **2017** which locks the second body to the protrusion **2010** at a desired location. A slot **2024** extends through the second body. When the second body **2012** is operatively assembled to the first body **2008** and the cutting guide **2000** is secured to a humeral head, slot **2024** corresponds to the planar surface **124** of humeral component **100**, or the planar surface of humeral components **200**, **300**, **400**, **500**, **600**. One or more holes **2046** may extend through the second body **2012** to receive fasteners **2094**, **2096** to fix the second body to the humerus prior to making any bone resections; three diverging holes **2046**, **2047**, **2048** are shown

Referring to FIG. **16**, a cutting guide **2100**, pin **900**, and four fasteners **2090**, **2092**, **2094**, **2096** are shown in an operative arrangement. The cutting guide **2100** may be referred to as a modular anterior-posterior or A-P cutting guide or as a modular medial-lateral or M-L cutting guide. The cutting guide **2100** may be used to guide a cutting tool, such as a saw blade, to cut two planar bone resections **20**, **24** corresponding to planar surfaces **120**, **124** of humeral component **100**, or the planar surfaces of humeral components **200**, **300**, **400**, **500**, **600**.

The cutting guide **2100** includes a shaft **2102** which extends between a proximal handle **2104** and a distal working portion **2106**. The working portion **2106** includes a first body **2108** and a rectangular second body **2112**. The first body **2108** includes the following features, which may be substantially similar to, or the same as, the corresponding features of the first body **2008**: bone-facing side **2109**; planar surface **2144**; slot **2120**; converging holes **2116**, **2146**; protrusion **2110**; and window **2111** or loop. A central socket or hole **2118** may receive shaft **2102**. The second body **2112** includes the following features, which may be substantially similar to, or the same as, the corresponding features of the second body **2012**: slot **2114**; fastener **2116**; slot **2124**; holes **2146**, **2147**, **2148**.

Referring to FIGS. **17**A-**17**C, a cutting guide **2300** and three fasteners **2390**, **2392**, **2394** are shown in an operative arrangement. The cutting guide **2300** may be referred to as a cut and drill guide or as a superior-inferior or S-I cutting guide. The cutting guide **2300** may be used to guide a cutting tool, such as a saw blade, to cut two planar bone resections **22**, **26** corresponding to planar surfaces **122**, **126** of humeral component **100**, or the planar surfaces of humeral components **200**, **300**, **400**, **500**, **600**. The cutting guide **2300** may also be used to guide a cutting tool, such as a drill or reamer, to cut bone holes **28**, **30**, **32** corresponding to anchoring elements **128**, **130**, **132** of humeral component **100**, or the anchoring elements of humeral components **200**, **300**, **400**, **500**, **600**.

The cutting guide **2300** includes a body **2308** with a bone-facing side **2309**. The bone-facing side **2309** includes intersecting planar surfaces **2320**, **2324**. Three holes **2328**, **2330**, **2332** extend lengthwise through the cutting guide **2300**, corresponding to the relative arrangement of anchoring elements **128**, **130**, **132** of humeral component **100**, or the anchoring elements of humeral components **200**, **300**, **400**, **500**, **600**. A fourth hole **2334** may be included in the cutting guide **2300**, corresponding to anchoring elements **434**, **534**, **634**. Two slots **2322**, **2326** extend obliquely through the cutting guide **2300**, corresponding to the relative arrangement of planar surfaces **122**, **126** of humeral component **100**, or the planar surfaces of humeral components **200**, **300**, **400**, **500**, **600**. One or more holes **2316** may extend through the cutting guide **2300** near opposing apices or ends of the body **2308** to receive fasteners **2392**, **2394** to fix the cutting guide **2300** to the humeral head prior to making any bone resections; two converging holes **2316**, **2346** are shown. A central hole **2318** may extend through the cutting guide **2300** to receive fastener **2390**. Fastener **2390** may be countersunk or otherwise recessed into the cutting guide **2300** to avoid occluding the slots **2322**, **2326**. Cutting guide **2300** may be secured by fastener **2390** alone, by fasteners **2392**, **2394**, by any two of fasteners **2390**, **2392**, **2394**, or by all three fasteners.

Referring to FIG. **18**, a cutting guide **2400** and two fasteners **2492**, **2494** are shown in an operative arrangement. The cutting guide **2400** may be referred to as a cut and drill guide or as a superior-inferior or S-I cutting guide. The cutting guide **2400** may be used to guide a cutting tool, such as a saw blade, to cut two planar bone resections **22**, **26** corresponding to planar surfaces **122**, **126** of humeral component **100**, or the planar surfaces of humeral components **200**, **300**, **400**, **500**, **600**. The cutting guide **2400** may also be used to guide a cutting tool, such as a drill or reamer, to cut bone holes **28**, **30**, **32** corresponding to anchoring elements **128**, **130**, **132** of humeral component **100**, or the anchoring elements of humeral components **200**, **300**, **400**, **500**, **600**.

The cutting guide **2400** includes a shaft **2402** which extends between a proximal handle **2404** and a distal working portion **2406**. The distal working portion **2406** may be releasably or permanently coupled to the shaft **2402** by threads or by releasable connection mechanisms. The distal working portion **2406** includes the following features, which may be substantially similar to, or the same as, the corresponding features of the cutting guide **2300**: body **2408**; bone-facing side **2409**; intersecting planar surfaces **2420**, **2424** (not visible in FIG. **18**); holes **2428**, **2430**, **2432**, **2434**; slots **2422**, **2426**; and converging holes **2416**, **2446**. The slots **2422**, **2426** extend obliquely through the cutting guide **2400**, corresponding to the relative arrangement of planar surfaces **122**, **126** of humeral component **100**, or the planar surfaces of humeral components **200**, **300**, **400**, **500**, **600**. A central socket or hole **2418** may receive shaft **2402**.

Referring to FIGS. **19**A-**19**B, a cutting guide **2500** and three fasteners **2590**, **2592**, **2594** are shown in FIG. **19**B in an operative arrangement. The cutting guide **2500** may be referred to as a cut and drill guide. The cutting guide **2500** may be used to guide a cutting tool, such as a saw blade, to cut three planar bone resections **62**, **64**, **66** corresponding to planar surfaces **762**, **764**, **766** of humeral component **700**, or planar surfaces **862**, **864**, **866** of humeral component **800**. The cutting guide **2500** may also be used to guide a cutting tool, such as a drill or reamer, to cut bone holes **68**, **70**, **72** corresponding to anchoring elements **768**, **770**, **772** of humeral component **700**, or anchoring elements **868**, **870**, **872** of humeral component **800**.

The cutting guide **2500** includes a star-shaped body **2508** with a bone-facing side **2509** which includes a planar surface **2544**. Three holes **2568**, **2570**, **2572** extend lengthwise through the cutting guide **2500**, corresponding to the relative arrangement of anchoring elements **768**, **770**, **772** of humeral component **700**, or anchoring elements **868**, **870**, **872** of humeral component **800**. Three slots **2562**, **2564**, **2566** extend obliquely through the cutting guide **2500**, corresponding to the relative arrangement of planar surfaces **762**, **764**, **766** of humeral component **700**, or planar surfaces **862**, **864**, **866** of humeral component **800**. One or more holes **2516** may extend through a central portion of the cutting guide **2500** to receive fasteners **2590**, **2592**, **2594** to fix the cutting guide **2500** to the humeral head prior to making any bone resections or holes; three skew holes **2546**, **2547**, **2548** are shown. The fasteners **2590**, **2592**, **2594** may be countersunk or otherwise recessed into the cutting guide **2500** to avoid occluding the slots **2562**, **2564**, **2566**. A central hole **2518** may extend through the cutting guide **1800** to receive pin **900**.

Referring to FIGS. **20**A-**20**B, a proximal humerus **2** includes a humeral head **4**. Referring to FIGS. **21**A-**26**B, a method of preparing a proximal humerus for implantation of a humeral component **100**, **200**, **300**, **400**, **500**, **600** may include some or all of the steps of cutting a first planar bone resection **20** to remove a posterior aspect of the humeral head **4**; cutting a second planar bone resection **22** to remove an inferior aspect of the humeral head **4**; cutting a third planar bone resection **24** to remove an anterior aspect of the humeral head **4**; cutting a fourth planar bone resection **26** to remove a superior aspect of the humeral head **4**; cutting a first bone hole **28** in an inferior aspect of the humeral head **4**; cutting second bone hole **30** in an anterior aspect of the humeral head **4**; cutting a third bone hole **32** in a posterior aspect of the humeral head **4**; and cutting a conical bone resection **74** on the humeral head **4** (as shown in FIG. **42**). The steps may be performed in any order, and additional steps may be performed.

With continued reference to FIGS. **21**A-**26**B, with brief reference to FIGS. **12**A-**12**J, another method of preparing a proximal humerus for implantation of a humeral component **100**, **200**, **300**, **400**, **500**, **600** may include some or all of the steps of placing the bone-facing side **1609** of the cutting guide **1600** against an intact humeral head **4**; aligning the cutting guide **1600** in a desired orientation relative to the intact proximal humeral anatomy so that the projections **1656**, **1657**, **1658** contact the humeral head; securing the cutting guide **1600** to the proximal humerus by driving at least one pin through any of the holes **1616**, **1646**, **1647**, **1648**, **1649**, **1650**, **1651**, **1652**, **1653**, **1654**; cutting four planar bone resections **20**, **22**, **24**, **26** by actuating a saw through each slot **1620**, **1622**, **1624**, **1626**; cutting three bone holes **28**, **30**, **32** by actuating a drill through each hole **1628**, **1630**, **1632**; removing the pins, the cutting guide **1600**, and bone fragments or debris; and optionally cutting a conical bone resection **74** with conical reamer **1500**.

Additional methods of preparing a proximal humerus for implantation of a humeral component may include some or all of the steps of establishing a humeral head axis; cutting anterior and posterior planar bone resections; cutting superior and inferior planar bone resections; and cutting bone holes. Each step is described below as a separate method.

Referring to FIGS. **27**-**29**, with brief reference to FIGS. **9**A-**9**B, a method of establishing a humeral head axis **6** may include some or all of the steps of placing the bone-facing side **1020** of the template **1000** against an intact humeral head **40**, which is shown in simplified form as a hemisphere; aligning the humeral shaft extension **1112** of the alignment guide **1100** with the humeral shaft; aligning the articular bar **1114** of the alignment guide **1100** with the articular margin of the humeral head **40**; aligning the template **1000** in a desired orientation relative to the intact proximal humeral anatomy so that the projections **1024**, **1026**, **1028** contact the humeral head **40**, wherein aligning the template **1000** may include aligning the shaft **1002** parallel with the post **1116**; driving the pin **900** through the cannulation **1030** and into the humeral head **40**; and removing the template **1000** and alignment guide **1100**. FIG. **29** shows the simplified humeral head **40** with a central bone hole **18** created by driving the pin **900** into the humeral head **40**. The humeral head axis **6** is the central longitudinal axis of the hole **18**, and may be normal to a central portion of the intact articular surface of the humeral head **40**, or parallel to the humeral neck axis.

Referring to FIGS. **30** and **31**, with brief reference to FIGS. **10**A-**10**B, a method of cutting a planar bone resection **44** may occur after the method of establishing the humeral head axis **6**, and may include some or all of the steps of inserting the pin **900** into the cannulation **1430** of the planar reamer **1400**; advancing the planar reamer **1400** over the pin **900** to contact the humeral head **40**; cutting the planar bone resection **44** by actuating the planar reamer **1400** until the continuous smooth planar surface **1434**, or the inner edge **1436** of the surface, contacts the humeral head to stop further bone removal by the planar reamer **1400**; and removing the planar reamer. FIG. **31** shows the simplified humeral head **40** with the planar bone resection **44** around the bone hole **18**. The planar bone resection **44** is normal to the humeral head axis **6**.

Referring to FIGS. **32** and **35**, with brief reference to FIGS. **13**A-**14**, a method of cutting anterior and posterior planar bone resections **20**, **24** may occur after the method of cutting the planar bone resection **44**, and may include some or all of the steps of inserting the pin **900** into the central hole **1818** of the cutting guide **1800**; advancing the cutting guide **1800** over the pin **900** to contact the humeral head **40**, wherein the planar surface **1844** contacts the planar bone resection **44**; securing the cutting guide **1800** to the humeral head **40** by driving at least one fastener **1890**, **1892** through any of the holes **1816**, **1846**; removing the pin **900**; cutting two planar bone resections **20**, **24** by actuating a saw through each slot **1820**, **1824**; and removing the fastener(s) **1890**, **1892** and the cutting guide **1800**. FIG. **35** shows the simplified humeral head **40** with the planar bone resections **20**, **24**. Cutting guide **1800** may be replaced by cutting guide **1900** in this method, in which case the shaft **1902** and handle **1904** may be used to push the distal working portion **1906** against the humeral head **40** for added stability during one or more of the steps of securing the cutting guide **1900** to the humeral head **40**; removing the pin **900**; and cutting two planar bone resections **20**, **24**.

Referring to FIGS. **33**-**35**, with brief reference to FIGS. **15**A-**16**, another method of cutting anterior and posterior planar bone resections **20**, **24** may occur after the method of cutting the planar bone resection **44**, and may include some or all of the steps of inserting the pin **900** into the central hole **2018** of the first body **2008** of the cutting guide **2000**; advancing the first body **2008** over the pin **900** to contact the humeral head **40**, wherein the planar surface **2044** contacts the planar bone resection **44**; securing the first body **2008** to the humeral head **40** by driving at least one fastener **2090**, **2092** through any of the holes **2016**, **2046**; removing the pin **900**; inserting the protrusion **2010** into the slot **2014** of the second body **2012**; advancing the second body **2012** over the protrusion **2010** to contact the humeral head **40**; securing the second body **2012** to the protrusion **2010** by actuating the fastener **2017**; securing the second body **2012** to the humeral head by driving at least one fastener **2094**, **2096** through any of the holes **2046**, **2047**, **2048**; cutting two planar bone resections **20**, **24** by actuating a saw through each slot **2020**, **2024**; and removing the fastener(s) **2090**, **2092**, **2094**, **2096** and the cutting guide **2000**. FIG. **35** shows the simplified humeral head **40** with the planar bone resections **20**, **24**. Cutting guide **2000** may be replaced by cutting guide **2100** in this method, in which case the shaft **2102** and handle **2104** may be used to push the first body **2008** against the humeral head **40** for added stability during one or more of the steps of securing the first body **2108** to the humeral head **40**; removing the pin **900**; inserting the protrusion **2110** into the slot **2114** of the second body **2112**; advancing the second body **2112** over the protrusion **2110** to contact the humeral head **40**; securing the second body **2112** to the protrusion **2110**; securing the second body **2112** to the humeral head; and cutting two planar bone resections **20**, **24**.

Referring to FIGS. **36**-**38**, with brief reference to FIGS. **17**A-**18**, a method of cutting superior and inferior planar bone resections **22**, **26** and bone holes **28**, **30**, **32**, **34** may occur after the method of cutting anterior and posterior planar bone resections **20**, **24**, and may include some or all of the steps of placing the cutting guide **2300** against the humeral head **40** so that the planar surface **2320** contacts the planar bone resection **20** and the planar surface **2324** contacts the planar bone resection **24**; securing the cutting guide **2300** to the humeral head **40** by driving at least one fastener **2390**, **2392**, **2394** through any of the holes **2316**, **2318**, **2346**; cutting two planar bone resections **22**, **26** by actuating a saw through each slot **2322**, **2326**; cutting four bone holes **28**, **30**, **32**, **34** by actuating a drill through holes **2328**, **2330**, **2332**, **2334**; and removing the fastener(s) **2390**, **2392**, **2394** and the cutting guide **2300**. FIG. **38** shows the simplified humeral head **40** with the planar bone resections **22**, **26** and bone holes **28**, **30**, **32**, **34**. Cutting guide **2300** may be replaced by cutting guide **2400** in this method, in which case the shaft **2402** and handle **2404** may be used to push the cutting guide **2400** against the humeral head **40** for added stability during one or more of the steps of securing the cutting guide **2300** to the humeral head **40**; cutting two planar bone resections **22**, **26**; and cutting four bone holes **28**, **30**, **32**, **34**.

Referring to FIGS. **39**-**40**, with brief reference to FIGS. **19**A-**19**B, a method of cutting inferior, antero-superior, and postero-superior planar bone resections **64**, **62**, **66** and bone holes **70**, **68**, **72** may occur after the method of cutting the planar bone resection **44**, and may include some or all of the steps of inserting the pin **900** into the central hole **2518** of the cutting guide **2500**; advancing the cutting guide **2500** over the pin **900** to contact the humeral head **4**, wherein the planar surface **2544** contacts the planar bone resection **44**; securing the cutting guide **2500** to the humeral head **4** by driving at least one fastener **2590**, **2592**, **2594** through any of the holes **2546**, **2547**, **2548**; removing the pin **900**; cutting three planar bone resections **62**, **64**, **66** by actuating a saw through holes **2562**, **2564**, **2566**; cutting three bone holes **68**, **70**, **72** by actuating a drill through each hole **68**, **70**, **72**; and removing the cutting guide **2500** and fastener(s) **2590**, **2592**, **2594**. FIG. **40** shows the humeral head **4** with the planar bone resections **62**, **64**, **66** and bone holes **68**, **70**, **72**.

Referring to FIGS. **41**-**42**, with brief reference to FIGS. **11**A-**11**B, a method of cutting a conical bone resection **74** may occur after any of the methods of cutting planar bone resections and/or bone holes, and is illustrated as if it occurs after the method of cutting inferior, antero-superior, and postero-superior planar bone resections **64**, **62**, **66** and bone holes **70**, **68**, **72**. The method of cutting the conical bone resection **74** may include some or all of the steps of inserting the pin **900** into the cannulation **1530** of the conical reamer **1500**; advancing the conical reamer **1500** over the pin **900** to contact the humeral head **4**; cutting the conical bone resection **74** by actuating the conical reamer **1500** until the planar surface **1514** contacts the humeral head to stop further bone removal by the conical reamer **1500**, wherein the planar surface **1514** may contact the planar surface **44**; and removing the conical reamer. FIG. **42** shows the humeral head **4** with the conical bone resection **74** around the humeral head **4**.

Referring to FIG. **43**, humeral component **700** is shown implanted on the humeral head **4** of FIG. **42**.

The components disclosed herein may be fabricated from metals, alloys, polymers, plastics, ceramics, glasses, composite materials, or combinations thereof, including but not limited to: PEEK, titanium, titanium alloys, commercially pure titanium grade 2, ASTM F67, Nitinol, cobalt chrome, stainless steel, ultra high molecular weight polyethylene (UHM-

WPE), biocompatible materials, and biodegradable materials, among others. Different materials may be used for different parts. Coatings may be present. Different materials may be used within a single part. Any component disclosed herein may be colored, coded or otherwise marked to make it easier for a user to identify the type and size of the component, the setting, the function(s) of the component, and the like.

It should be understood that the present systems, kits, apparatuses, and methods are not intended to be limited to the particular forms disclosed. Rather, they are to cover all combinations, modifications, equivalents, and alternatives falling within the scope of the claims.

The claims are not to be interpreted as including means-plus- or step-plus-function limitations, unless such a limitation is explicitly recited in a given claim using the phrase(s) "means for" or "step for," respectively.

The term "coupled" is defined as connected, although not necessarily directly, and not necessarily mechanically.

The use of the word "a" or "an" when used in conjunction with the term "comprising" in the claims and/or the specification may mean "one," but it is also consistent with the meaning of "one or more" or "at least one." The term "about" means, in general, the stated value plus or minus 5%. The use of the term "or" in the claims is used to mean "and/or" unless explicitly indicated to refer to alternatives only or the alternative are mutually exclusive, although the disclosure supports a definition that refers to only alternatives and "and/or."

The terms "comprise" (and any form of comprise, such as "comprises" and "comprising"), "have" (and any form of have, such as "has" and "having"), "include" (and any form of include, such as "includes" and "including") and "contain" (and any form of contain, such as "contains" and "containing") are open-ended linking verbs. As a result, a method or device that "comprises," "has," "includes" or "contains" one or more steps or elements, possesses those one or more steps or elements, but is not limited to possessing only those one or more elements. Likewise, a step of a method or an element of a device that "comprises," "has," "includes" or "contains" one or more features, possesses those one or more features, but is not limited to possessing only those one or more features. Furthermore, a device or structure that is configured in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

In the foregoing Detailed Description, various features are grouped together in several examples for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the examples of the invention require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed example. Thus, the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate example.

The invention claimed is:

1. An arthroplasty prosthesis comprising:

an articular surface; and

a bone-facing side opposite the articular surface;

wherein the bone-facing side comprises a concave arrangement of at least three planar surfaces, wherein the at least three planar surfaces converge toward the articular surface, wherein the first planar surface intersects the second planar surface along a first line, wherein the second planar surface intersects the third planar surface along a second line, wherein the third planar surface intersects the first planar surface along a third line, wherein the first, second, and third lines converge together as the first, second, and third lines approach the articular surface, wherein the at least three planar surfaces intersect the articular surface to establish an articular margin of the prosthesis, wherein the articular margin includes an indentation located where a selected one of the at least three planar surfaces intersects the articular surface.

2. The prosthesis of claim **1**, wherein the at least three planar surfaces intersect each other.

3. The prosthesis of claim **1**, wherein, when the prosthesis is operatively implanted with the bone-facing side facing a prepared humeral head and the articular surface facing into a shoulder joint, the indentation faces and is spaced apart from at least a portion of a rotator cuff.

4. The prosthesis of claim **1**, wherein the bone-facing side comprises a concave arrangement of at least four planar surfaces.

5. The prosthesis of claim **4**, wherein the at least four planar surfaces converge toward the articular surface.

6. The prosthesis of claim **4**, wherein three of the at least four planar surfaces are radially arranged about a remaining one of the at least four planar surfaces.

7. The prosthesis of claim **1**, wherein the articular surface has a shape selected from the group consisting of a spherical shape, an ellipsoid shape, and an ovoid shape.

8. The prosthesis of claim **1**, wherein the at least three planar surfaces converge toward a central portion of the articular surface, wherein the at least three planar surfaces intersect a peripheral portion of the articular surface to establish the articular margin of the prosthesis.

9. An arthroplasty prosthesis comprising:

an articular surface; and

a bone-facing side opposite the articular surface, wherein the bone-facing side comprises a first planar surface, a second planar surface, and a third planar surface, wherein the first, second, and third planar surfaces converge toward a center of the articular surface and diverge toward a perimeter of the articular surface, wherein the first planar surface intersects the second planar surface along a first line, wherein the second planar surface intersects the third planar surface along a second line, wherein the third planar surface intersects the first planar surface along a third line, wherein the first and second lines intersect, wherein the first, second, and third lines converge.

10. The prosthesis of claim **9**, wherein the first, second, and third planar surfaces converge toward the articular surface.

11. The prosthesis of claim **9**, wherein the bone-facing side comprises a fourth planar surface, wherein the fourth planar surface intersects at least one planar surface along a third line, wherein the at least one planar surface is selected from the group consisting of the first, second, and third planar surface.

12. The prosthesis of claim **11**, wherein the first, second, third, and fourth planar surfaces are in a concave arrangement and converge toward the articular surface.

13. The prosthesis of claim **11**, wherein the first, second, and third planar surfaces are radially arranged about the fourth planar surface.

14. The prosthesis of claim **9**, wherein the articular surface has a shape selected from the group consisting of a spherical shape, an ellipsoid shape, and an ovoid shape.

15. An arthroplasty prosthesis comprising:

an articular surface; and

a bone-facing side opposite the articular surface, wherein the bone-facing side comprises a socket with at least three planar side walls, wherein the at least three planar side walls taper inwardly as the socket extends from the bone-facing side toward the articular surface, wherein the at least three planar side walls intersect a perimeter of the articular surface, wherein the at least three planar side walls intersect each other.

16. The prosthesis of claim **15**, wherein the socket comprises a fourth planar wall.

17. The prosthesis of claim **16**, wherein the fourth planar wall is a side wall, wherein the at least three planar side walls and the fourth planar wall converge toward the articular surface.

18. The prosthesis of claim **16**, wherein the at least three planar side walls are radially arranged about the fourth planar wall.

19. The prosthesis of claim **15**, wherein the articular surface has a shape selected from the group consisting of a spherical shape, an ellipsoid shape, and an ovoid shape.

20. The prosthesis of claim **15**, wherein the at least three planar side walls taper inwardly as the socket extends from the bone-facing side toward a central portion of the articular surface.

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